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The Department of Defense

DoD Departments:

Department of the Navy

Department of the Air Force

Ballistic Missile Defense Organization

Special Operations Command

DARPA

Defense Advanced Research Projects Agency

CBD

Joint Chemical Biological Defense

Defense Threat Reduction Agency

PROGRAM SOLICITATION 99.1
CLOSING DATE: 13 JANUARY 1999

FY 1999 SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM

PROGRAM SOLICITATION

Number 99.1

Small Business Innovation Research Program

IMPORTANT

The DoD updates its SBIR mailing list annually. To remain on the mailing list or to be added to the list, send in the Mailing List form (Reference G) found at the back of this solicitation or complete the electronic form at http://www.teltech.com/sbir/form.html. Failure to send the form annually will result in removal of your name from the mailing list.

If you have questions about the Defense Department's SBIR program, please call the SBIR/STTR Help Desk at (800) 382-4634, or see the DoD SBIR/STTR Home Page, at http://www.acq.osd.mil/sadbu/sbir.

U.S. Department of Defense
SBIR Program Office
Washington, DC 20301

October 1, 1998:	Solicitation issued for public release
December 1, 1998:	DoD begins accepting proposals
January 13, 1999:	Deadline for receipt of proposals at the DoD Components by 2:00 p.m. local time

OFFICE OF THE UNDER SECRETARY OF DEFENSE

3000 DEFENSE PENTAGON
WASHINGTON DC 20301-3000

ACQUISITION AND TECHNOLOGY

IMPORTANT NEW INFORMATION ABOUT THE DOD SBIR PROGRAM

1. **The DoD SBIR/STTR Help Desk** can address your questions about this solicitation, the proposal preparation process, contract negotiations, getting paid, government accounting requirements, intellectual property protection, the Fast Track, obtaining outside financing, and other program-related areas. You may contact the Help Desk by:

   Phone: 800-382-4634 (8AM to 8PM EST)
   Fax: 800-462-4128
   Email: SBIRHELP@us.teltech.com

2. **The DoD SBIR/STTR Home Page (http://www.acq.osd.mil/sadbu/sbir)** offers electronic access to the SBIR solicitations, hyperlinks to the Component SBIR programs within DoD, answers to commonly-asked questions about contracting with the government, sample SBIR proposals, model SBIR contracts, abstracts of SBIR projects funded between 1983 and 1998, the latest updates on the SBIR program, information on the Small Business Technology Transfer (STTR) program, hyperlinks to the laws and regulations referenced in this solicitation, hyperlinks to sources of business assistance and financing, and other useful information.

3. **The SBIR "Fast Track" policy has been revised and streamlined since the FY 1997 solicitations.** The new Fast Track procedures are discussed in Sections 4.3 and 4.5 of this solicitation. Under the Fast Track policy, SBIR projects that attract some matching cash from an outside investor for the Phase II effort have a significantly higher chance of Phase II award and also receive expedited processing and interim funding between Phases I and II to ensure no delay in reaching the market. For the latest Fast Track results/statistics, see the DoD SBIR Home Page.

4. **You may contact the DoD authors of solicitation topics to ask questions about the topics** before you submit a proposal. Procedures for doing so are discussed in Section 1.5(c) of this solicitation. Please note that you may talk by telephone with a topic author to ask such questions only between October 1, when this solicitation was publicly released, and December 1, when DoD begins accepting proposals. At other times, you may submit written questions, and all such questions and the responses will be posted electronically on the Home Page for general viewing.

5. **An SBIR proposal that meets the goals of a solicitation topic but does not use the exact approach specified in the topic will still be considered.** For further information on this new DoD policy, see Section 4.1 of this solicitation.

6. **DoD has reduced delays in the SBIR proposal evaluation and contracting process by nearly 40 percent over the past two years.** The median time between proposal receipt and award is now less than 4 months in Phase I and 6.5 months in Phase II.

7. **Before DoD can award your company a contract under this solicitation, your company must be registered in the DoD Central Contractor Registration database.** To register, see http://ccr.edi.disa.mil or call 1-888-227-2423.

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DoD PROGRAM SOLICITATION FOR SMALL BUSINESS INNOVATION RESEARCH

1.0 PROGRAM DESCRIPTION

1.1 Introduction

The Navy, Air Force, Defense Advanced Research Projects Agency (DARPA), Ballistic Missile Defense Organization (BMDO), Defense Threat Reduction Agency (DTRA), U.S. Special Operations Command (SOCOM), and Joint Chemical Biological Defense (CBD), hereafter referred to as DoD Components, invite small business firms to submit proposals under this solicitation for the Small Business Innovation Research (SBIR) program. Firms with the capability to conduct research and development (R&D) in any of the defense-related topic areas described in Section 8.0, and to commercialize the results of that R&D, are encouraged to participate.

Objectives of the DoD SBIR Program include stimulating technological innovation, strengthening the role of small business in meeting DoD research and development needs, fostering and encouraging participation by minority and disadvantaged persons in technological innovation, and increasing the commercial application of DoD-supported research or research and development results.

The Federal SBIR Program is mandated by Public Laws PL 97-219, PL 99-443, and PL 102-564. The basic design of the DoD SBIR Program is in accordance with the Small Business Administration (SBA) SBIR Policy Directive, January 1993. The DoD Program presented in this solicitation strives to encourage scientific and technical innovation in areas specifically identified by DoD Components. The guidelines presented in this solicitation incorporate and exploit the flexibility of the SBA Policy Directive to encourage proposals based on scientific and technical approaches most likely to yield results important to the DoD and the private sector.

1.2 Three Phase Program

This program solicitation is issued pursuant to the Small Business Innovation Development Act of 1982, PL 97-219, PL 99-443, and PL 102-564. Phase I is to determine, insofar as possible, the scientific, technical, and commercial merit and feasibility of ideas submitted under the SBIR Program. Phase I awards are typically $60,000 to $100,000 in size over a period not to exceed six months (nine months for the Air Force). Proposals should concentrate on that research or research and development which will significantly contribute to proving the scientific, technical, and commercial feasibility of the proposed effort, the successful completion of which is a prerequisite for further DoD support in Phase II. The measure of Phase I success includes evaluations of the extent to which Phase II results would have the potential to yield a product or process of continuing importance to DoD and the private sector. Proposers are encouraged to consider whether the research or research and development they are proposing to DoD Components also has private sector potential, either for the proposed application or as a base for other applications.

Subsequent Phase II awards will be made to firms on the basis of results of their Phase I effort and the scientific, technical, and commercial merit of the Phase II proposal. Phase II awards are typically $500,000 to $750,000 in size over a period generally not to exceed 24 months (subject to negotiation). Phase II is the principal research or research and development effort and is expected to produce a well-defined deliverable prototype. A more comprehensive proposal will be required for Phase II.

Under Phase III, the small business is expected to obtain funding from the private sector and/or non-SBIR Government sources to develop the prototype into a viable product or non-R&D service for sale in military and/or private sector markets.

This solicitation is for Phase I proposals only. Only proposals submitted in response to this solicitation will be considered for Phase I award. Proposers who were not awarded a contract in response to a prior SBIR solicitation are free to update or modify and re-submit the same or modified proposal if it is responsive to any of the topics listed in Section 8.0.

For Phase II, no separate solicitation will be issued and no unsolicited proposals will be accepted. Only those firms that were awarded Phase I contracts will be considered (Section 4.3 and 5.2).

DoD is not obligated to make any awards under either Phase I, II, or III, and all awards are subject to the availability of funds. DoD is not responsible for any monies expended by the proposer before award of any contract.

1.3 Proposer Eligibility and Limitations

Each proposer must qualify as a small business for research or research and development purposes as defined in Section 2.0 and certify to this on the Cover Sheet (Appendix A) of the proposal. In addition, a minimum of two-thirds of the research and/or analytical work in Phase I must be carried out by the proposing firm. For Phase II, a minimum of one-half of the research and/or analytical work must be performed by the proposing firm. The percent of work is usually measured by both direct and indirect costs, although proposers planning to subcontract a significant fraction of

their work should verify how it will be measured with their DoD contracting officer during contract negotiations. For both Phase I and II, the primary employment of the principal investigator must be with the small business firm at the time of the award and during the conduct of the proposed effort. Primary employment means that more than one-half of the principal investigator's time is spent with the small business. Primary employment with a small business concern precludes full-time employment at another organization. Deviations from the requirements in this paragraph must be approved in writing by the contracting officer (during contract negotiations).

For both Phase I and Phase II, all research or research and development work must be performed by the small business concern in the United States. "United States" means the fifty states, the Territories and possessions of the United States, the Commonwealth of Puerto Rico, the Commonwealth of the Northern Mariana Islands, the Trust Territory of the Pacific Islands, and the District of Columbia.

Joint ventures and limited partnerships are permitted, provided that the entity created qualifies as a small business in accordance with the Small Business Act, 15 USC 631, and the definition included in Section 2.2.

1.4 Conflicts of Interest

Awards made to firms owned by or employing current or previous Federal Government employees could create conflicts of interest for those employees in violation of 18 USC and 10 USC 2397. Such proposers should contact the cognizant Ethics Counselor from the employees' Government agency for further guidance.

1.5 Questions about SBIR and Solicitation Topics

a. General Questions/Information. The DoD SBIR/STTR Help Desk is prepared to address general questions about this solicitation, the proposal preparation process, contract negotiation, payment vouchers, Government accounting requirements, intellectual property protection, the Fast Track, financing strategies, and other program-related areas. The Help Desk may be contacted by:

Phone: 800-382-4634 (8AM to 8PM EST)
Fax: 800-462-4128
Email: SBIRHELP@us.teltech.com

The DoD SBIR/STTR Home Page offers electronic access to SBIR solicitations, answers to commonly asked questions, sample SBIR proposals, model SBIR contracts, abstracts of ongoing SBIR projects, the latest updates on the SBIR program, hyperlinks to sources of business assistance and financing, and other useful information.

DOD SBIR/STTR HOME PAGE:
http://www.acq.osd.mil/sadbu/sbir

b. General Questions about a DoD Component. General questions pertaining to a particular DoD Component (Army, Navy, Air Force, etc) should be submitted in accordance with the instructions given at the beginning of that Component's topics, in Section 8.0 of this solicitation.

c. Technical Questions about Solicitation Topics. On October 1, 1998, this solicitation was issued for public release on the DoD SBIR/STTR Home Page (**http://www.acq.osd.mil/sadbu/sbir**), along with the names of the topic authors and their phone numbers. The names of topic authors and their phone numbers will remain posted on the Home Page until December 1, 1998, giving proposers an opportunity to ask technical questions about specific solicitation topics by telephone.

Once DoD begins accepting proposals on December 1, 1998, telephone questions will no longer be accepted, but proposers may submit written questions through the SBIR Interactive Topic Information System (SITIS), in which the questioner and respondent remain anonymous and all questions and answers are posted electronically for general viewing. Proposers may submit written questions to SITIS via internet (see shortcut bar at the top of the DoD SBIR/STTR Home Page), e-mail, fax, mail, or telephone as follows:

Defense Technical Information Center
MATRIS Office, DTIC-AM
ATTN: SITIS Coordinator
53355 Cole Road
San Diego, CA 92152-7213
Phone: (619) 553-7006
Fax: (619) 553-7053
E-mail: sbir@dticam.dtic.mil
www: http://dticam.dtic.mil/sbir/

The SITIS service for this solicitation opens on or around October 15, 1998 and closes to new questions on January 5, 1999. SITIS will post all questions and answers on the Internet (see shortcut bar at the top of the DoD SBIR/STTR Home Page) from October 15, 1998 through January 13, 1999. (Answers will also be emailed or faxed directly to the inquirer if the inquirer provides an e-mail address or fax number.) Answers are generally posted within seven working days of question submission.

All proposers are advised to monitor SITIS during the solicitation period for questions and answers, and other information, relevant to the topic under which they are proposing.

1.6 Requests for Copies of DoD SBIR Solicitation

To remain on the DoD Mailing list for the SBIR and STTR solicitations, send in the Mailing List form (Reference G). You may also order additional copies of this solicitation from:

DoD SBIR Support Services
2850 Metro Drive, Suite 600
Minneapolis, MN 55425-1566
(800) 382-4634

The DoD SBIR and STTR solicitations can also be accessed via internet through the DoD SBIR/STTR Home Page at **http://www.acq.osd.mil/sadbu/sbir**.

1.7 SBIR Conferences and Outreach

The DoD holds three National SBIR Conferences a year and participates in many state-organized conferences for small business. For information on these events, see our Home Page (**http://www.acq.osd.mil/sadbu/sbir**). We have a special outreach effort to socially and economically disadvantaged firms.

2.0 DEFINITIONS

The following definitions apply for the purposes of this solicitation:

2.1 Research or Research and Development

Basic Research - Scientific study and experimentation to provide fundamental knowledge required for the solution of problems.

Exploratory Development - A study, investigation or minor development effort directed toward specific problem areas with a view toward developing and evaluating the feasibility and practicability of proposed solutions.

Advanced Development - Proof of design efforts directed toward projects that have moved into the development of hardware for test.

Engineering Development - Full-scale engineering development projects for DoD use but which have not yet received approval for production.

2.2 Small Business

A small business concern is one that, at the time of award of a Phase I or Phase II contract:

a. Is independently owned and operated and organized for profit, is not dominant in the field of operation in which it is proposing, and has its principal place of business located in the United States;

b. Is at least 51% owned, or in the case of a publicly owned business, at least 51% of its voting stock is owned by United States citizens or lawfully admitted permanent resident aliens;

c. Has, including its affiliates, a number of employees not exceeding 500, and meets the other regulatory requirements found in 13 CFR Part 121. Business concerns, other than investment companies licensed, or state development companies qualifying under the Small Business Investment Act of 1958, 15 USC 661, et seq., are affiliates of one another when either directly or indirectly (1) one concern controls or has the power to control the other; or (2) a third party or parties controls or has the power to control both. Control can be exercised through common ownership, common management, and contractual relationships. The term "affiliates" is defined in greater detail in 13 CFR Sec. 121.103. The term "number of employees" is defined in 13 CFR Sec. 121.106. Business concerns include, but are not limited to, any individual, partnership, corporation, joint venture, association or cooperative.

2.3 Socially and Economically Disadvantaged Small Business

A small business that is at the time of award of a Phase I or Phase II contract:

a. At least 51% owned by an Indian tribe or a native Hawaiian organization, or one or more socially and economically disadvantaged individuals, and

b. Whose management and daily business operations are controlled by one or more socially and economically disadvantaged individuals.

A socially and economically disadvantaged individual is defined as a member of any of the following groups: Black Americans, Hispanic Americans, Native Americans, Asian-Pacific Americans, Subcontinent-Asian Americans, or other groups designated by SBA to be socially and economically disadvantaged.

2.4 Women-Owned Small Business

A women-owned small business is one that is at least 51% owned by a woman or women who also control and operate it. "Control" in this context means exercising the power to make policy decisions. "Operate" in this context

means being actively involved in the day-to-day management of the business.

2.5 Funding Agreement

Any contract, grant, or cooperative agreement entered into between any Federal Agency and any small business concern for the performance of experimental, developmental, or research work funded in whole or in part by the federal Government. *Only the contract method will be used by DoD components for all SBIR awards.*

2.6 Subcontract

A subcontract is any agreement, other than one involving an employer-employee relationship, entered into by a Federal Government contract awardee calling for supplies or services required solely for the performance of the original contract. This includes consultants.

2.7 Commercialization

The process of developing a product or non-R&D service for sale (whether by the originating party or by others), in Government and/or private sector markets.

3.0 PROPOSAL PREPARATION INSTRUCTIONS AND REQUIREMENTS

3.1 Proposal Requirements

A proposal to any DoD Component under the SBIR Program is to provide sufficient information to persuade the DoD Component that the proposed work represents an innovative approach to the investigation of an important scientific or engineering problem and is worthy of support under the stated criteria.

The quality of the scientific or technical content of the proposal will be the principal basis upon which proposals will be evaluated. The proposed research or research and development must be responsive to the chosen topic, although need not use the exact approach specified in the topic (see Section 4.1). Any small business contemplating a bid for work on any specific topic should determine that (a) the technical approach has a reasonable chance of meeting the topic objective, (b) this approach is innovative, not routine, and (c) the firm has the capability to implement the technical approach, i.e. has or can obtain people and equipment suitable to the task.

Those responding to this solicitation should note the proposal preparation tips listed below:

- Read and follow all instructions contained in this solicitation, including the instructions in Section 8.0 of the DoD component to which you are applying.
- Use the free technical information services from DTIC and other information assistance organizations (Section 7.1 - 7.4).
- Mark proprietary information as instructed in Sec. 5.6.
- Limit your proposal to 25 pages (excluding Company Commercialization Report).
- Use a type size no smaller than 12 pitch or 11 point.
- Do not include proprietary or classified information in the project summary (Appendix B).
- Include a copy of Appendix A, Appendix B, and Appendix E as part of the original of each proposal. (Additional copies of all Appendices can be downloaded from **http://www.acq.osd.mil/sadbu/sbir**).
- Do not use a proportionally spaced font on Appendix A and Appendix B.

3.2 Proprietary Information

If information is provided which constitutes a trade secret, proprietary commercial or financial information, confidential personal information, or data affecting the national security, it will be treated in confidence to the extent permitted by law, provided it is clearly marked in accordance with Section 5.6.

3.3 Limitations on Length of Proposal

This solicitation is designed to reduce the investment of time and cost to small firms in preparing a formal proposal. Those who wish to respond must submit a direct, concise, and informative research or research and development proposal of no more than 25 pages, excluding Company Commercialization Report (Appendix E), (no type smaller than 11 point or 12 pitch on standard 8½" X 11" paper with one (1) inch margins, and a maximum of 6 lines per inch), *including Proposal Cover Sheet (Appendix A), Project Summary (Appendix B), Cost Proposal (Appendix C), and any enclosures or attachments.* Promotional and non-project related discussion is discouraged. Cover all items listed below in Section 3.4 in the order given. The space allocated to each will depend on the problem chosen and the principal investigator's approach. In the interest of equity, proposals in excess of the 25-page limitation (including attachments, appendices, or references, but excluding Company Commercialization Report (Appendix E) will not be considered for review or award.

3.4 Phase I Proposal Format

All pages shall be consecutively numbered and the ORIGINAL of each proposal must contain a completed copy of Appendix A, Appendix B and Appendix E.

a. Cover Sheet. Complete and sign Appendix A, photocopy the completed form, and use a copy as Page 1 of each additional copy of your proposal.

b. Project Summary. Complete Appendix B, photocopy the completed form, and use a copy as Page 2 of each additional copy of your proposal. The technical abstract should include a brief description of the project objectives and description of the effort. Anticipated benefits and commercial applications of the proposed research or research and development should also be summarized in the space provided. The Project Summaries of proposals selected for award will be publicly released on the Internet and, therefore, should not contain proprietary or classified information.

c. Identification and Significance of the Problem or Opportunity. Define the specific technical problem or opportunity addressed and its importance. (Begin on Page 3 of your proposal.)

d. Phase I Technical Objectives. Enumerate the specific objectives of the Phase I work, including the questions it will try to answer to determine the feasibility of the proposed approach.

e. Phase I Work Plan. Provide an explicit, detailed description of the Phase I approach. The plan should indicate what is planned, how and where the work will be carried out, a schedule of major events, and the final product to be delivered. The Phase I effort should attempt to determine the technical feasibility of the proposed concept. The methods planned to achieve each objective or task should be discussed explicitly and in detail. This section should be a substantial portion of the total proposal.

f. Related Work. Describe significant activities directly related to the proposed effort, including any conducted by the principal investigator, the proposing firm, consultants, or others. Describe how these activities interface with the proposed project and discuss any planned coordination with outside sources. The proposal must persuade reviewers of the proposer's awareness of the state-of-the-art in the specific topic.

Describe previous work not directly related to the proposed effort but similar. Provide the following: (1) short description, (2) client for which work was performed (including individual to be contacted and phone number), and (3) date of completion.

g. Relationship with Future Research or Research and Development.

(1) State the anticipated results of the proposed approach if the project is successful.
(2) Discuss the significance of the Phase I effort in providing a foundation for Phase II research or research and development effort.

h. Commercialization Strategy. Describe, in approximately one page, your company's strategy for converting your proposed SBIR research into a product or non-R&D service with widespread commercial use -- including private sector and/or military markets.

I. Key Personnel. Identify key personnel who will be involved in the Phase I effort including information on directly related education and experience. A concise resume of the principal investigator, including a list of relevant publications (if any), must be included.

j. Facilities/Equipment. Describe available instrumentation and physical facilities necessary to carry out the Phase I effort. Items of equipment to be purchased (as detailed in Appendix C) shall be justified under this section. Also state whether or not the facilities where the proposed work will be performed meet environmental laws and regulations of federal, state (name), and local Governments for, but not limited to, the following groupings: airborne emissions, waterborne effluents, external radiation levels, outdoor noise, solid and bulk waste disposal practices, and handling and storage of toxic and hazardous materials.

k. Consultants. Involvement of a university or other consultants in the project may be appropriate. If such involvement is intended, it should be described in detail and identified in Appendix C. A minimum of two-thirds of the research and/or analytical work in Phase I, as measured by direct and indirect costs, must be carried out by the proposing firm, unless otherwise approved in writing by the contracting officer.

l. Prior, Current, or Pending Support of Similar Proposals or Awards. *Warning* -- While it is permissible, with proposal notification, to submit identical proposals or proposals containing a significant amount of essentially equivalent work for consideration under numerous federal program solicitations, it is unlawful to enter into contracts or grants requiring essentially equivalent effort. If there is any question concerning this, it must be disclosed to the soliciting agency or agencies before award.

If a proposal submitted in response to this solicitation is substantially the same as another proposal that has been funded, is now being funded, or is pending with another Federal Agency or DoD Component or the same DoD Component, the proposer must so indicate on Appendix A and provide the following information:

(1) Name and address of the Federal Agency(s) or DoD Component to which a proposal was submitted, will be submitted, or from which an award is expected or has been received.
(2) Date of proposal submission or date of award.
(3) Title of proposal.
(4) Name and title of principal investigator for each proposal submitted or award received.
(5) Title, number, and date of solicitation(s) under which the proposal was submitted, will be submitted, or under which award is expected or has been received.
(6) If award was received, state contract number.
(7) Specify the applicable topics for each SBIR proposal submitted or award received.

Note: If Section 3.4.1 does not apply, state in the proposal "No prior, current, or pending support for proposed work."

m. Cost Proposal. Complete the cost proposal in the form of Appendix C for the Phase I effort only. Some items of Appendix C may not apply to the proposed project. If such is the case, there is no need to provide information on each and every item. What matters is that enough information be provided to allow the DoD Component to understand how the proposer plans to use the requested funds if the contract is awarded.

(1) List all key personnel by name as well as by number of hours dedicated to the project as direct labor.
(2) Special tooling and test equipment and material cost may be included under Phases I and II. The inclusion of equipment and material will be carefully reviewed relative to need and appropriateness for the work proposed. The purchase of special tooling and test equipment must, in the opinion of the Contracting Officer, be advantageous to the Government and should be related directly to the specific topic. These may include such items as innovative instrumentation and/or automatic test equipment. Title to property furnished by the Government or acquired with Government funds will be vested with the DoD Component, unless it is determined that transfer of title to the contractor would be more cost effective than recovery of the equipment by the DoD Component.
(3) Cost for travel funds must be justified and related to the needs of the project.
(4) Cost sharing is permitted for proposals under this solicitation; however, cost sharing is not required nor will it be an evaluation factor in the consideration of a Phase I proposal.

When a proposer is selected for award the proposer should be prepared to submit further documentation to its DoD contracting officer to substantiate costs (e.g., a brief explanation of cost estimates for equipment, materials, and consultants or subcontractors).

n. Company Commercialization Report on Prior SBIR Awards. All small business concerns submitting a Phase I or Phase II proposal must complete Appendix E (Company Commercialization Report), listing the commercialization status of all of the concern's prior Phase II efforts. (This required proposal information shall not be counted toward proposal pages count limitations.) A Report showing that a small business concern has received no prior Phase II awards will not affect the concern's ability to obtain an SBIR award.

3.5 Bindings

Do not use special bindings or covers. Staple the pages in the upper left hand corner of each proposal.

3.6 Phase II Proposal Format

This solicitation is for Phase I only. A Phase II proposal can be submitted only by a Phase I awardee and only in response to a request from the agency; that is, Phase II is not initiated by a solicitation.

Each Phase II proposal must contain a Cover Sheet (Appendix A), a Project Summary Sheet (Appendix B), and a Company Commercialization Report (Appendix E). In addition, each Phase II proposal must contain a two-page commercialization strategy, addressing the following questions:

(1) What is the first product that this technology will go into?
(2) Who will be your customers, and what is your estimate of the market size?
(3) How much money will you need to bring the technology to market, and how will you raise that money?
(4) Does your company contain marketing expertise and, if not, how do you intend to bring that expertise into the company?
(5) Who are your competitors, and what is your price and/or quality advantage over your competitors?

Copies of Appendices along with additional instructions regarding Phase II proposal preparation and submission will be provided or made available by the DoD Components to all Phase I winners at time of Phase I contract award.

3.7 False Statements

Knowingly and willfully making any false, fictitious, or fraudulent statements or representations may be a felony under the Federal Criminal False Statement Act (18 U.S.C. Sec 1001), punishable by a fine of up to $10,000, up to five years in prison, or both.

4.0 METHOD OF SELECTION AND EVALUATION CRITERIA

4.1 Introduction

Phase I proposals will be evaluated on a competitive basis and will be considered to be binding for six (6) months from the date of closing of this solicitation unless the offeror states otherwise. If selection has not been made prior to the proposal's expiration date, offerors will be requested as to whether or not they want to extend their proposal for an additional period of time. Proposals meeting stated solicitation requirements will be evaluated by scientists or engineers knowledgeable in the topic area. Proposals will be evaluated first on their relevance to the chosen topic. A proposal that meets the goals of a solicitation topic but does not use the exact approach specified in the topic will be considered relevant. (Prospective proposers should contact the topic author as described in Section 1.5 to determine whether submission of such a proposal would be useful.)

Proposals found to be relevant will then be evaluated using the criteria listed in Section 4.2. Final decisions will be made by the DoD Component based upon these criteria and consideration of other factors including possible duplication of other work, and program balance. A DoD Component may elect to fund several or none of the proposed approaches to the same topic. In the evaluation and handling of proposals, every effort will be made to protect the confidentiality of the proposal and any evaluations. There is no commitment by the DoD Components to make any awards on any topic, to make a specific number of awards or to be responsible for any monies expended by the proposer before award of a contract.

For proposals that have been selected for contract award, a Government Contracting Officer will draw up an appropriate contract to be signed by both parties before work begins. Any negotiations that may be necessary will be conducted between the offeror and the Government Contracting Officer. It should be noted that only a duly appointed contracting officer has the authority to enter into a contract on behalf of the U.S. Government.

Phase II proposals will be subject to a technical review process similar to Phase I. Final decisions will be made by DoD Components based upon the scientific and technical evaluations and other factors, including a commitment for Phase III follow-on funding, the possible duplication with other research or research and development, program balance, budget limitations, and the potential of a successful Phase II effort leading to a product of continuing interest to DoD. DoD is not obligated to make any awards under Phase II or the Fast Track, and all awards are subject to the availability of funds. DoD is not responsible for any monies expended by the proposer before award of a contract.

Upon written request and after final award decisions have been announced, a debriefing will be provided to unsuccessful offerors on their proposals.

4.2 Evaluation Criteria - Phase I

The DoD Components plan to select for award those proposals offering the best value to the Government and the nation considering the following factors.

a. The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution.

b. The qualifications of the proposed principal/key investigators, supporting staff, and consultants. Qualifications include not only the ability to perform the research and development but also the ability to commercialize the results.

c. The potential for commercial (Government or private sector) application and the benefits expected to accrue from this commercialization.

Where technical evaluations are essentially equal in merit, cost to the Government will be considered in determining the successful offeror.

Technical reviewers will base their conclusions only on information contained in the proposal. It cannot be assumed that reviewers are acquainted with the firm or key individuals or any referenced experiments. Relevant supporting data such as journal articles, literature, including Government publications, etc., should be contained or referenced in the proposal.

4.3 Evaluation Criteria - Phase II

The Phase II proposal will be reviewed for overall merit based upon the criteria below.

a. The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution.

b. The qualifications of the proposed principal/key investigators, supporting staff, and consultants. Qualifications include not only the ability to perform the research and development but also the ability to commercialize the results.

c. The potential for commercial (Government or private sector) application and the benefits expected to accrue from this commercialization.

The reasonableness of the proposed costs of the effort to be performed will be examined to determine those proposals that offer the best value to the Government. Where technical evaluations are essentially equal in merit, cost to the Government will be considered in determining the successful offeror.

Phase II proposal evaluation may include on-site evaluations of the Phase I effort by Government personnel.

Fast Track Phase II proposals. Under the regular Phase II evaluation process, the above three criteria are each given roughly equal weight (with some variation across the DoD

Components). For projects that qualify for the Fast Track (as discussed in Section 4.5), DoD will evaluate the Phase II proposals under a separate, expedited process in accordance with the above criteria, and will select these proposals for Phase II award provided:

(1) they meet or exceed a threshold of "technically sufficient" for criteria (a) and (b); and
(2) the project has substantially met its Phase I technical goals

(and assuming budgetary and other programmatic factors are met, as discussed in Section 4.1). Fast Track proposals, having attracted matching cash from an outside investor, presumptively meet criterion (c). Consistent with DoD policy, this process should result in a significantly higher percentage of Fast Track projects obtaining Phase II award than non-Fast Track projects.

4.4 Assessing Commercial Potential of Proposals

A Phase I or Phase II proposal's commercial potential can be evidenced by:

- **a.** The small business concern's record of commercializing SBIR or other research, particularly as reflected in its Company Commercialization Report (Appendix E).
- **b.** The existence of second phase funding commitments from private sector or non-SBIR funding sources.
- **c.** The existence of third phase follow-on commitments for the subject of the research.
- **d.** The presence of other indicators of commercial potential of the idea, including the small business' commercialization strategy (discussed in Sections 3.4.h and 3.6, above).

If a company chooses to submit a third phase follow-on commitment per (c.) above, the commitment should state that the small business or a third party will provide follow-on funding in Phase III, and indicate the dates on which the funds will be made available. The commitment should also contain specific technical objectives which, if achieved in Phase II, will make the commitment exercisable by the small business. The terms should not be contingent upon the obtaining of a patent due to the length of time this process requires. The funding commitment should be submitted with the Phase II proposal.

4.5 SBIR Fast Track

a. In General. On a pilot basis, the DoD SBIR program has implemented a streamlined Fast Track process for SBIR projects that attract matching cash from an outside investor for the Phase II SBIR effort (as well as for the interim effort between Phases I and II). The purpose is to focus SBIR funding on those projects that are most likely to be developed into viable new products that DoD and others will buy and that will thereby make a major contribution to U.S. military and/or economic capabilities.

Outside investors, as defined in DoD's Fast Track Guidance (Reference E), may include such entities as another company, a venture capital firm, an individual investor, or a non-SBIR, non-STTR government program; they do not include the owners of the small business, their family members, and/or affiliates of the small business.

As discussed in detail below, projects that obtain matching funds from outside investors and thereby qualify for the SBIR Fast Track will (subject to the qualifications described herein):

(1) Receive interim funding of $30,000 to $50,000 between Phases I and II;
(2) Be evaluated for Phase II award under a separate, expedited process; and
(3) Be selected for Phase II award provided they meet or exceed a threshold of "technically sufficient" and have substantially met their Phase I technical goals (and assuming other programmatic factors are met), as described in Section 4.3.

Consistent with DoD policy, this process should prevent any significant gaps in funding between Phases I and II for Fast Track projects, and result in a significantly higher percentage of Fast Track projects obtaining Phase II award than non-Fast Track projects.

All DoD Components administer the Fast Track according to the procedures in this section, except for BMDO. BMDO administers slightly different procedures that have been approved by the Under Secretary of Defense for Acquisition and Technology -- see the BMDO section of this solicitation.

b. How To Qualify for the SBIR Fast Track. To qualify for the SBIR Fast Track, a company must submit a Fast Track application within 150 days after the effective start date of its Phase I contract, unless a different deadline for Fast Track applications is specified by the DoD Component funding the project (see the Component's introductory page in Section 8 of this solicitation - the deadlines range from 120 to 180 days). The company is encouraged to discuss the application with its Phase I technical monitor; however, it need not wait for an invitation from the technical monitor to submit either a Fast Track application or a Fast Track Phase II proposal.

A Fast Track application consists of the following items:

(1) A completed Fast Track application form, found at Appendix D. On the application form, the company and its outside investor must:

    (a) State that the outside investor will match both interim and Phase II SBIR funding, in cash, contingent on the company's selection for Phase II award, as described on the form at Appendix D. The matching rates needed to qualify for the Fast Track are as follows:

- For companies that have never received a Phase II SBIR award from DoD or any other federal agency, the minimum matching rate is 25 cents for every SBIR dollar. (For example, if such a company receives interim and Phase II SBIR funding that totals $750,000, it must obtain matching funds from the investor of $187,500.)

- For all other companies, the minimum matching rate is 1 dollar for every SBIR dollar. (For example, if such a company receives interim and Phase II SBIR funding that totals $750,000, it must obtain matching funds from the investor of $750,000.)

(b) Certify that the outside funding proposed in the application qualifies as a "Fast Track investment," and the investor qualifies as an "outside investor," as defined in DoD Fast Track Guidance (Reference E).

(2) A letter from the outside investor to the company, containing:

(a) A commitment to match both interim and Phase II SBIR funding, in cash, contingent on the company's selection for Phase II award, as discussed on the form at Appendix D.
(b) A brief statement (less than one page) describing that portion of the effort that the investor will fund. The investor's funds may pay for additional research and development on the company's SBIR project or, alternatively, they may pay for other activities not included in the Phase II contract's statement of work, provided these activities further the development and/or commercialization of the technology (e.g., marketing).
(c) A brief statement (less than one page) describing (i) the investor's experience in evaluating companies' ability to successfully commercialize technology; and (ii) the investor's assessment of the market for this particular SBIR technology, and of the ability of the company to bring this technology to market.

(3) A concise statement of work for the interim SBIR effort (less than four pages) and detailed cost proposal (less than one page). Note: if the company has already negotiated an interim effort (e.g., an "option") of $30,000 to $50,000 with DoD as part of its Phase I contract, it need only cite that section of its contract, and need not submit an additional statement of work and cost proposal.

The company should send its Fast Track application to its Phase I technical monitor, with copies to the appropriate Component program manager and to the DoD SBIR program manager, as indicated on the back of the application form.

Also, in order to qualify for the Fast Track, the company:

(1) Must submit its Phase II proposal within 180 days after the effective start date of its Phase I contract, unless a different deadline for Fast Track Phase II proposals is specified by the DoD Component funding the contract (see the Component's introductory page in Section 8 of this solicitation - the deadlines range from 150 days to 210 days).
(2) Must submit its Phase I final report by the deadline specified in its Phase I contract, but not later than 210 days after the effective start date of the contract.
(3) Must certify, within 45 days after being notified that it has been selected for Phase II award, that the entire amount of the matching funds from the outside investor has been transferred to the company. Certification consists of a letter, signed by both the company and its outside investor, stating that "$______ in cash has been transferred to our company from our outside investor in accord with the SBIR Fast Track procedures." The letter must be sent to the DoD contracting office along with a copy of the company's bank statement showing the funds have been deposited. IMPORTANT: If the DoD contracting office does not receive, within the 45 days, this certification showing the transfer of funds, the company will be ineligible to compete for a Phase II award not only under the Fast Track but also under the regular Phase II competition, unless a specific written exception is granted by the Component's SBIR program manager. Before signing the certification letter, the company and investor should read the cautionary note at Section 3.7. If the outside investor is a non-SBIR/non-STTR DoD program, it must provide a line of accounting within the 45 days that can be accessed immediately.

Failure to meet these conditions in their entirety and within the time frames indicated will generally disqualify a company from participation in the SBIR Fast Track. Deviations from these conditions must be approved in writing by the contracting office.

c. Benefits of Qualifying for the Fast Track. If a project qualifies for the Fast Track:

(1) It will receive interim SBIR funding of $30,000 to $50,000, commencing approximately at the end of Phase I. Consistent with DoD policy, the vast majority of projects that qualify for the Fast Track should receive interim SBIR funding. However, the DoD contracting office has the discretion and authority, in any particular instance, to deny interim funding when doing so is in the Government's interest (e.g., when the project no longer meets a military need or the statement of work does not meet the threshold of "technically sufficient" as described in Section 4.3).
(2) DoD will evaluate the Fast Track Phase II proposal under a separate, expedited process, and will select the proposal for Phase II award provided it meets or exceeds a threshold of "technically sufficient" for

evaluation criteria (a) and (b), as described in Section 4.3 (assuming budgetary and other programmatic factors are met, as discussed in Section 4.1). Consistent with DoD policy, this process should result in a significantly higher percentage of Fast Track projects obtaining Phase II award than non-Fast Track projects. However, DoD is not obligated, in any particular instance, to award a Phase II contract to a Fast Track project, and DoD is not responsible for any funds expended by the proposer before award of a contract.

(3) It will receive notification, no later than ten weeks after the completion of its Phase I project, of whether it has been selected for a Phase II award.

(4) If selected, it will receive its Phase II award within an average of five months from the completion of its Phase I project.

d. Additional Reporting Requirement. In the company's final Phase II progress report, it must include a brief accounting (in the company's own format) of how the investor's funds were expended to support the project.

5.0 CONTRACTUAL CONSIDERATIONS

Note: Eligibility and Limitation Requirements (Section 1.3) Will Be Enforced

5.1 Awards (Phase I)

a. Number of Phase I Awards. The number of Phase I awards will be consistent with the agency's RDT&E budget, the number of anticipated awards for interim Phase I modifications, and the number of anticipated Phase II contracts. No Phase I contracts will be awarded until all qualified proposals (received in accordance with Section 6.2) on a specific topic have been evaluated. All proposers will be notified of selection/non-selection status for a Phase I award no later than July 13, 1999. *The DoD Components anticipate making 650 Phase I awards from this solicitation.* On average, 1 in 8 Phase I proposals receive funding.

b. Type of Funding Agreement. All winning proposals will be funded under negotiated contracts and may include a fee or profit. The firm fixed price or cost plus fixed fee type contract will be used for all Phase I projects (see Section 5.5). *Note: The firm fixed price contract is the preferred type for Phase I.*

c. Average Dollar Value of Awards. DoD Components will make Phase I awards to small businesses typically on a one-half person-year effort over a period generally not to exceed six months (subject to negotiation). PL 102-564 allows agencies to award Phase I contracts up to $100,000 without justification. The typical size of award varies across the DoD Components; <u>it is therefore important for a proposer to read the introductory page of the Component to which it is applying (in Section 8.0) for any specific instructions regarding award size</u>.

5.2 Awards (Phase II)

a. Number of Phase II Awards. The number of Phase II awards will depend upon the results of the Phase I efforts and the availability of funds. *The DoD Components anticipate that approximately 40 percent of its Phase I awards will result in Phase II projects.*

b. Type of Funding Agreement. Each Phase II proposal selected for award will be funded under a negotiated contract and may include a fee or profit.

c. Average Dollar Value of Awards. Phase II awards will be made to small businesses based on results of the Phase I efforts and the scientific, technical, and commercial merit of the Phase II proposal. Average Phase II awards will typically cover 2 to 5 person-years of effort over a period generally not to exceed 24 months (subject to negotiation). PL 102-564 states that the Phase II awards may be up to $750,000 each without justification. <u>See special instructions for each DoD Component in Section 8.</u>

5.3 Phase I Report

a. Content. A final report is required for each Phase I project. The report must contain in detail the project objectives, work performed, results obtained, and estimates of technical feasibility. A completed SF 298, "Report Documentation Page", will be used as the first page of the report. (A blank SF298 is provided in Section 9.0, Reference D.) In addition, monthly status and progress reports may be required by the DoD agency.

b. Preparation.

(1) If desirable, language used by the company in its Phase II proposal to report Phase I progress may also be used in the final report.

(2) For each unclassified report, the company submitting the report should fill in block 12a (Distribution/Availability Statement) of the SF298, "Report Documentation Page" with one of the following statements:

(a) Approved for public release; distribution unlimited.

(b) Distribution authorized to U.S. Government Agencies only; contains proprietary information.

Note: The sponsoring DoD activity, after reviewing the company's entry in block 12a, has final responsibility

for assigning a distribution statement.

(3) Block 13 (Abstract) of the SF 298, "Report Documentation Page") must include as the first sentence, "Report developed under SBIR contract for topic [insert solicitation topic number]". The abstract must identify the purpose of the work and briefly describe the work carried out, the finding or results and the potential applications of the effort. Since the abstract will be published by the DoD, it must not contain any proprietary or classified data.

(4) Block 14 (Subject Terms) of the SF 298 must include the term "SBIR Report".

c. Submission. The company shall submit FIVE COPIES of the final report on each Phase I project to the DoD in accordance with the negotiated delivery schedule. Delivery will normally be within thirty days after completion of the Phase I technical effort. The company shall, at the same time, submit ONE ADDITIONAL COPY of each report directly to the DTIC:

ATTN:DTIC-OCA
Defense Technical Information Center
8725 John J Kingman Road, Suite 0944
Ft. Belvoir, VA 22060-6218.

If the report is classified, the sponsoring DoD activity will provide special submission instructions. *Note: The sponsoring DoD activity has final responsibility for ensuring that the company or the DoD activity provide DTIC with all applicable Phase I and Phase II technical reports, classified and unclassified, developed under SBIR contract, per DoD Directive 3200.12 (http://web7.whs.osd.mil/dodiss/directives/direct2.htm).*

5.4 Other Reports

If asked, the contractor will be required to provide DoD with a report during Phase II, and each year for five years after completion of Phase II, detailing: (1) the revenue from sales of new products or non-R&D services resulting from the SBIR project, and (2) the sources and amounts of non-SBIR, non-STTR funding received from the Government and/or private sector sources to further develop the SBIR technology.

5.5 Payment Schedule

The specific payment schedule (including payment amounts) for each contract will be incorporated into the contract upon completion of negotiations between the DoD and the successful Phase I or Phase II offeror. Successful offerors may be paid periodically as work progresses in accordance with the negotiated price and payment schedule. Phase I contracts are primarily fixed price contracts, under which monthly payments may be made. The contract may include a separate provision for payment of a fee or profit. Final payment will follow completion of contract performance and acceptance of all work required under the contract. Other types of financial assistance may be available under the contract.

5.6 Markings of Proprietary or Classified Proposal Information

The proposal submitted in response to this solicitation may contain technical and other data which the proposer does not want disclosed to the public or used by the Government for any purpose other than proposal evaluation.

Information contained in unsuccessful proposals will remain the property of the proposer except for Appendices A and B. The Government may, however, retain copies of all proposals. Public release of information in any proposal submitted will be subject to existing statutory and regulatory requirements.

If proprietary information is provided by a proposer in a proposal which constitutes a trade secret, proprietary commercial or financial information, confidential personal information or data affecting the national security, it will be treated in confidence, to the extent permitted by law, provided this information is clearly marked by the proposer with the term "confidential proprietary information" and provided that the following legend which appears on the title page (Appendix A) of the proposal is completed:

> "For any purpose other than to evaluate the proposal, this data except Appendix A and B shall not be disclosed outside the Government and shall not be duplicated, used, or disclosed in whole or in part, provided that if a contract is awarded to the proposer as a result of or in connection with the submission of this data, the Government shall have the right to duplicate, use or disclose the data to the extent provided in the contract. This restriction does not limit the Government's right to use information contained in the data if it is obtained from another source without restriction. The data subject to this restriction is contained in page(s)_________of this proposal."

Any other legend may be unacceptable to the Government and may constitute grounds for removing the proposal from further consideration and without assuming any liability for inadvertent disclosure. The Government will limit dissemination of properly marked information to within official channels.

In addition, each page of the proposal containing proprietary data which the proposer wishes to restrict must be marked with the following legend:

> "Use or disclosure of the proposal data on lines specifically identified by asterisk (*) are subject to the restriction on the cover page of this proposal."

If all of the information on a particular page is proprietary, the proposer should so note by including the word "PROPRIETARY" in both the header and footer on that

page.

The Government assumes no liability for disclosure or use of unmarked data and may use or disclose such data for any purpose.

In the event properly marked data contained in a proposal in response to this solicitation is requested pursuant to the Freedom of Information Act, 5 USC 552, the proposer will be advised of such request and prior to such release of information will be requested to expeditiously submit to the DoD Component a detailed listing of all information in the proposal which the proposer believes to be exempt from disclosure under the Act. Such action and cooperation on the part of the proposer will ensure that any information released by the DoD Component pursuant to the Act is properly determined.

Those proposers that have a classified facility clearance may submit classified material with their proposal. Any classified material shall be marked and handled in accordance with applicable regulations. Arbitrary and unwarranted use of this restriction is discouraged. Offerors must follow the Industrial Security Manual for Safeguarding Classified Information (DoD 5220.22M) procedures for marking and handling classified material.

5.7 Copyrights

To the extent permitted by statute, the awardee may copyright (consistent with appropriate national security considerations, if any) material developed with DoD support. DoD receives a royalty-free license for the Federal Government and requires that each publication contain an appropriate acknowledgment and disclaimer statement.

5.8 Patents

Small business firms normally may retain the principal worldwide patent rights to any invention developed with Government support. The Government receives a royalty-free license for its use, reserves the right to require the patent holder to license others in certain limited circumstances, and requires that anyone exclusively licensed to sell the invention in the United States must normally manufacture it domestically. To the extent authorized by 35 USC 205, the Government will not make public any information disclosing a Government-supported invention for a period of five years to allow the awardee to pursue a patent.

5.9 Technical Data Rights

Rights in technical data, including software, developed under the terms of any contract resulting from proposals submitted in response to this solicitation generally remain with the contractor, except that the Government obtains a royalty-free license to use such technical data only for Government purposes during the period commencing with contract award and ending five years after completion of the project under which the data were generated. Upon expiration of the five-year restrictive license, the Government has unlimited rights in the SBIR data. During the license period, the Government may not release or disclose SBIR data to any person other than its support services contractors except: (1) For evaluational purposes; (2) As expressly permitted by the contractor; or (3) A use, release, or disclosure that is necessary for emergency repair or overhaul of items operated by the Government. See FAR clause 52.227-20, "Rights in Data - SBIR Program" and DFARS 252.227-7018, "Rights in Noncommercial Technical Data and Computer Software -- SBIR Program."

5.10 Cost Sharing

Cost sharing is permitted for proposals under this solicitation; however, cost sharing is not required nor will it be an evaluation factor in the consideration of any Phase I proposal.

5.11 Joint Ventures or Limited Partnerships

Joint ventures and limited partnerships are eligible provided the entity created qualifies as a small business as defined in Section 2.2 of this solicitation.

5.12 Research and Analytical Work

a. For Phase I a minimum of two-thirds of the research and/or analytical work must be performed by the proposing firm unless otherwise approved in writing by the contracting officer.

b. For Phase II a minimum of one-half of the research and/or analytical work must be performed by the proposing firm, unless otherwise approved in writing by the contracting officer.

The percentage of work is usually measured by both direct and indirect costs, although proposers planning to subcontract a significant fraction of their work should verify how it will be measured with their contracting officer during contract negotiations.

5.13 Contractor Commitments

Upon award of a contract, the contractor will be required to make certain legal commitments through acceptance of Government contract clauses in the Phase I contract. The outline that follows is illustrative of the types of provisions required by the Federal Acquisition Regulations that will be included in the Phase I contract. This is not a complete list of provisions to be included in Phase I contracts, nor does it contain specific wording of these clauses. Copies of complete general provisions will be made available prior to award.

a. Standards of Work. Work performed under the contract must conform to high professional standards.

b. Inspection. Work performed under the contract is subject to Government inspection and evaluation at all reasonable times.

c. Examination of Records. The Comptroller General (or a fully authorized representative) shall have the right to examine any directly pertinent records of the contractor involving transactions related to this contract.

d. Default. The Government may terminate the contract if the contractor fails to perform the work contracted.

e. Termination for Convenience. The contract may be terminated at any time by the Government if it deems termination to be in its best interest, in which case the contractor will be compensated for work performed and for reasonable termination costs.

f. Disputes. Any dispute concerning the contract which cannot be resolved by agreement shall be decided by the contracting officer with right of appeal.

g. Contract Work Hours. The contractor may not require an employee to work more than eight hours a day or forty hours a week unless the employee is compensated accordingly (that is, receives overtime pay).

h. Equal Opportunity. The contractor will not discriminate against any employee or applicant for employment because of race, color, religion, sex, or national origin.

i. Affirmative Action for Veterans. The contractor will not discriminate against any employee or applicant for employment because he or she is a disabled veteran or veteran of the Vietnam era.

j. Affirmative Action for Handicapped. The contractor will not discriminate against any employee or applicant for employment because he or she is physically or mentally handicapped.

k. Officials Not to Benefit. No member of or delegate to Congress shall benefit from the contract.

l. Covenant Against Contingent Fees. No person or agency has been employed to solicit or secure the contract upon an understanding for compensation except bona fide employees or commercial agencies maintained by the contractor for the purpose of securing business.

m. Gratuities. The contract may be terminated by the Government if any gratuities have been offered to any representative of the Government to secure the contract.

n. Patent Infringement. The contractor shall report each notice or claim of patent infringement based on the performance of the contract.

o. Military Security Requirements. The contractor shall safeguard any classified information associated with the contracted work in accordance with applicable regulations.

p. American Made Equipment and Products. When purchasing equipment or a product under the SBIR funding agreement, purchase only American-made items whenever possible.

5.14 Contractor Registration [NEW]

Before DoD can award a contract to a successful proposer under this solicitation, the proposer must be registered in the DoD Central Contractor Registration database. To register, see http://ccr.edi.disa.mil or call 1-888-227-2423.

5.15 Additional Information

a. General. This Program Solicitation is intended for informational purposes and reflects current planning. If there is any inconsistency between the information contained herein and the terms of any resulting <u>SBIR contract</u>, the terms of the contract are controlling.

b. Small Business Data. Before award of an SBIR contract, the Government may request the proposer to submit certain organizational, management, personnel, and financial information to confirm responsibility of the proposer.

c. Proposal Preparation Costs. The Government is not responsible for any monies expended by the proposer before award of any contract.

d. Government Obligations. This Program Solicitation is not an offer by the Government and does not obligate the Government to make any specific number of awards. Also, awards under this program are contingent upon the availability of funds.

e. Unsolicited Proposals. The SBIR Program is not a substitute for existing unsolicited proposal mechanisms. Unsolicited proposals will not be accepted under the SBIR Program in either Phase I or Phase II.

f. Duplication of Work. If an award is made pursuant to a proposal submitted under this Program Solicitation, the contractor will be required to certify that he or she has <u>not previously</u> been, nor is <u>currently</u> being, paid for essentially <u>equivalent work</u> by an agency of the Federal Government.

g. Classified Proposals. If classified work is proposed or classified information is involved, the offeror to the solicitation must have, or obtain, security clearance in accordance with the Industrial Security Manual for

Safeguarding Classified Information (DoD 5220.22M). The Manual is available on-line at **http://www.dis.mil** or in hard copy from:

Defense Investigative Service
1340 Braddock Place
Alexandria, VA 22314
Phone: (703) 325-5324

6.0 SUBMISSION OF PROPOSALS

An original plus (4) copies of each proposal or modification will be submitted, in a single package, as described below, unless otherwise stated by specific instructions in Section 8.0.

NOTE: THE ORIGINAL OF EACH PROPOSAL MUST CONTAIN A COMPLETED APPENDIX A (COVER SHEET), APPENDIX B (PROJECT SUMMARY), AND APPENDIX E (COMPANY COMMERCIALIZATION REPORT).

6.1 Address

Each proposal or modification thereof shall be submitted in sealed envelopes or packages addressed to that DoD Component address which is identified for the specific topic in that Component's subsection of Section 8.0 to this solicitation.

The name and address of the offeror, the solicitation number, the topic number for the proposal, and the time and date specified for proposal receipt must be clearly marked on the outside of the envelope or package. To protect your proposal against rough handling, damage in the mail, and the possibility of unauthorized disclosures, it is recommended that your proposal be double-wrapped and that both the inner and outer envelopes or wrappings be clearly marked.

Offerors using commercial carrier services shall ensure that the proposal is addressed and marked on the outermost envelope or wrapper as prescribed above.

Mailed or handcarried proposals must be delivered to the address indicated for each topic. Secured packaging is mandatory. The DoD Component cannot be responsible for the processing of proposals damaged in transit.

All copies of a proposal must be sent in the same package. Do not send separate information copies or several packages containing parts of the single proposal.

6.2 Deadline of Proposals

Deadline for receipt of proposals at the DoD Component is 2:00 p.m. local time, January 13, 1999. Any proposal received at the office designated in the solicitation after the exact time specified for receipt of offers will not be considered unless it is received before award is made and--

(a) It was sent by registered or certified mail not later than January 8, 1999;

(b) It was sent by mail or hand-carried (including delivery by a commercial carrier) and it is determined by the Government that the late receipt was due primarily to Government mishandling after receipt at the Government installation; or

(c) It was sent by U.S. Postal Service Express Mail Next Day Service-Post Office to Addressee, not later than 5:00 p.m. at the place of mailing on January 11, 1999.

Note: There are no other provisions for late receipt of proposals under this solicitation.

The only acceptable evidence to establish the date of mailing of a late proposal sent either by registered or certified mail is the U.S. Postal Service postmark both on the envelope or wrapper and on the original receipt from the U.S. Postal Service. Both postmarks must show a legible date or the proposal shall be processed as if mailed late. "Postmark" means a printed, stamped, or otherwise placed impression (exclusive of a postage meter machine impression) that is readily identifiable without further action as having been supplied and affixed by employees of the U.S. Postal Service on the date of mailing. Therefore, offerors or respondents should request the postal clerk to place a legible hand cancellation bull's eye postmark on both the receipt and the envelope or wrapper. Acceptable evidence to establish the time of receipt at the Government installation includes the time/date stamp of that installation on the proposal wrapper, other documentary evidence of receipt maintained by the installation, or oral testimony or statements of Government personnel. The only acceptable evidence to establish the date of mailing of a late proposal sent by Express Mail Next Day Service-Post Office to Addressee is the date entered by the post office receiving clerk on the "Express Mail Next Day Service-Post Office to Addressee" label and the postmark on both the envelope or wrapper and on the original receipt from the U.S. Postal Service. Therefore, offerors should request the postal clerk to place a legible hand cancellation bull's eye postmark on both the receipt and the envelope or wrapper.

Proposals may be withdrawn by written notice or a telegram received at any time prior to award. Proposals may also be withdrawn in person by an offeror or his authorized representative, provided his identity is made known and he signs a receipt for the proposal. *(Note: the term telegram includes mailgrams.)*

Any modification or withdrawal of a proposal is subject to the same conditions outlined above. Any modification may not make the proposal longer than 25 pages (excluding Company Commercialization Report). Notwithstanding the above, a late modification of an otherwise successful proposal which makes its terms more favorable to the Government will be considered at any time it is received and may be accepted.

6.3 Notification of Proposal Receipt

Proposers desiring notification of receipt of their proposal must complete and include a self-addressed stamped envelope and a copy of the notification form (Reference A) in the back of this brochure. If multiple proposals are submitted, a separate form and envelope is required for each. Notification of receipt of a proposal by the Government does not by itself constitute a determination that the proposal was received on time or not. The determination of timeliness is solely governed by the criteria set forth in Section 6.2.

6.4 Information on Proposal Status

Evaluation of proposals and award of contracts will be expedited, but no information on proposal status will be available until the final selection is made. However, contracting officers may contact any and all qualified proposers prior to contract award.

6.5 Debriefing of Unsuccessful Offerors

An unsuccessful offeror that submits a written request for a debriefing within 30 days of being notified that its proposal was not selected for award will be provided a debriefing. The written request should be sent to the DoD organization that provided such notification to the offeror. Be advised that an offeror that fails to submit a timely request is not entitled to a debriefing, although untimely debriefing requests may be accommodated at the government's discretion.

6.6 Correspondence Relating to Proposals

All correspondence relating to proposals should cite the SBIR solicitation number and specific topic number and should be addressed to the DoD Component whose address is associated with the specific topic number.

7.0 SCIENTIFIC AND TECHNICAL INFORMATION ASSISTANCE

7.1 DoD Technical Information Services Available

The Defense Technical Information Center (DTIC) provides information services to assist SBIR participants in proposal preparation, bid decisions, product development, marketing and networking. The following services are available at no cost to the SBIR user.

1. **Technical Information Packages (TIPs)**, bibliographic listings of related DoD-funded work are prepared for the majority of SBIR topics. Request TIPs in hard copy by mailing in Reference B at the back of this solicitation, or by telephone, fax or e-mail. Online TIPs (OLTIPS) are available on the DTIC SBIR web site **(http://www.dtic.mil/dtic/sbir).**

2. **Public STINET**, DTIC's online technical database, is on the web site. SBIR participants are encouraged to search the database for documents in their areas of interest.

3. **Full Text Documents** are also on the web site, including a large selection of SBIR related technical reports.

4. **TRAIL**, an e-mail document alert service available to SBIR/STTR participants, provides listings biweekly of new DTIC accessions matching the recipient's interests (http://www.dtic.mil/trail/).

5. **Free Reports**: A firm may receive a total of ten hard copy technical reports at no cost from DTIC during a solicitation period. Additional reports, custom bibliographies, and services requested during non-solicitation periods may be charged to a credit card or deposit account.

6. **SITIS**, providing answers to specific technical questions concerning DoD topic descriptions, is also on the web site. See the description of SITIS in Section 1.5.c.

DTIC is a major component of the DoD Scientific and Technical Information Program, managing the technical information resulting from DoD-funded research and development (http://www.dtic.mil). DTIC also manages and provides access to specialized information services and subject matter expertise. MATRIS, a DTIC component, is the focal point for information on manpower, training systems, human performance, and human factors **(http://dticam.dtic.mil).** The DTIC-managed Centers for Analysis of Scientific and Technical Information (the IACs) are the DoD centers of expertise concerned with engineering, technical and scientific documents and databases worldwide **(http://www.dtic.mil/iac/).**

Call or visit (by prearrangement) DTIC at the location most convenient to you. Written communications should be made to the Ft. Belvoir address.

ATTN: DTIC-SBIR
Defense Technical Information Center
8725 John J Kingman Road, Suite 0944
Ft. Belvoir, VA 22060-6218
Ph: (800) 363-7247
Fax: (703) 767-8228
Email: sbir@dtic.mil
www: http://www.dtic.mil/dtic/sbir

DTIC Northeastern Regional Office
Building 1103
5 Wright Street
Hanscom AFB, MA 01731-3012
Ph: (781) 377-2413
Fax: (781) 377-5627
Email: boston@dtic.mil

DTIC Southwestern Regional Office
AFRL-PSO/TL/STIC
3550 Aberdeen Ave, SE
Kirtland AFB, NM 87117-5776
Ph: (505) 846-6797
Fax: (505) 846-6799
Email: albuq@dtic.mil

DTIC Midwestern Regional Office
2690 C Street, Suite 4
Wright-Patterson AFB, OH 45433
Ph: (937) 255-7905
Fax: (937) 676-7002
Email: dayton@dtic.mil

DTIC Western Regional Office
222 N. Sepulveda Blvd., Suite 906
El Segundo, CA 90245-4320
Ph: (310) 335-4170
Fax: (310) 335-3663
Email: losangel@dtic.mil

7.2 Other Technical Information Assistance Sources

Other sources provide technology search and/or document services and can be contacted directly for service and cost information. These include:

National Technical Information Services
5285 Port Royal Road
Springfield, VA 22161
Ph: (703) 605-6000 or (800) 553-6847
Fax: (703) 321-8547
Email: infntis@fedworld.gov
www: www.ntis.gov

University of Southern California
Office of Patents and Copyright Administration
3716 South Hope Street, Suite 313
Los Angeles, CA 90007-4344
Ph: (213) 743-2282
Fax: (213) 744-1832
www: www.usc.edu/dept/Patents_Copyrights

Center for Technology Commercialization
1400 Computer Drive
Westborough, MA 01581-5043
Ph: (508) 870-0042
Fax: (508) 366-0101
www: www.ctc.org

Great Lakes Technology Transfer Center/Battelle
25000 Great Northern Corporate Center, Suite 260
Cleveland, OH 44070
Ph: (216) 734-0094
Fax: (216) 734-0686
www: www.battelle.org/glitec/

Midcontinent Technology Transfer Center
Texas Engineering Experiment Station
The Texas A&M University System
301 Tarrow, Suite 119
College Station, TX 77840-7896
Ph: (409) 845-8762
Fax: (409) 845-3559
www: www.tedd.org

Mid-Atlantic Technology Applications Center
University of Pittsburgh
3200 Forbes Avenue
Pittsburgh, PA 15260
Ph: (412) 383-2500
Fax: (412) 383-2595
www: www.mtac.pitt.edu

Southern Technology Application Center
University of Florida, College of Engineering
Box 24, 13709 Progress Boulevard
Alachua, FL 32615
Ph: (904) 462-3913
Ph: (800) 225-0308 (outside FL)
Fax: (904) 462-3898
www: www.state.fl.us/stac/

Federal Information Exchange, Inc.
555 Quince Orchard Road, Suite 360
Gaithersburg, MD 20878
Ph: (301) 975-0103
Fax: (301) 975-0109
www: www.rams-fie.com

7.3 DoD Counseling Assistance Available

Small business firms interested in participating in the SBIR Program may seek general administrative guidance from small and disadvantaged business utilization specialists located in various Defense Contract Management activities throughout the continental United States. These specialists are available to discuss general administrative requirements to facilitate the submission of proposals and ease the entry of the small high technology business into the Department of Defense marketplace. The small and disadvantaged business utilization specialists are expressly prohibited from taking any action which would give an offeror an unfair advantage over others, such as discussing or explaining the technical requirements of the solicitation, writing or discussing technical or cost proposals, estimating cost or any other actions which are the offerors responsibility as outlined in this solicitation. (See Reference C at the end of this solicitation for a complete listing, with telephone numbers, of Small and Disadvantaged Business Utilization Specialists assigned to these activities.)

7.4 State Assistance Available

Many states have established programs to provide services to those small firms and individuals wishing to participate in the Federal SBIR Program. These services vary from state to state, but may include:

- Information and technical assistance;
- Matching funds to SBIR recipients;
- Assistance in obtaining Phase III funding.

Contact your State Government Office of Economic Development for further information.

8.0 TECHNICAL TOPICS

Section 8 contains detailed topic descriptions outlining the technical areas in which DoD Components request proposals for innovative R&D from small businesses. Topics for each participating DoD Component are listed and numbered separately. Each DoD Component Topic Section contains topic descriptions, addresses of organizations to which proposals are to be submitted, and special instructions for preparing and submitting proposals to organizations within the Component. Read and follow these instructions carefully to help avoid administrative rejection of your proposal.

Appendices A, B, C, D and E follow the Component Topic Sections. Appendix A is a Proposal Cover Sheet, Appendix B is a Project Summary form, Appendix C is an outline for the Cost Proposal, Appendix D is the Fast Track Application Form, and Appendix E is the Company Commercialization Report. A completed copy of Appendix A, Appendix B, and Appendix E, as well as a completed Cost Proposal, must be included with each proposal submitted.

Many of the topics in Section 8 contain references to technical literature or military standards, which may be accessed as follows:

- References with "AD" numbers are available from DTIC, by calling 800/DoD-SBIR or sending an e-mail message to sbir@dtic.mil
- References with "MIL-STD" numbers are available from the Department of Defense Single Stock Point for Military Specifications, Standards and Related Publications at Internet address http://www.dodssp.daps.mil
- Other references can be found in your local library or at locations mentioned in the reference.

CHEMICAL AND BIOLOGICAL DEFENSE PROGRAM

General Information

In response to Congressional interest in the readiness and effectiveness of U.S. Nuclear, Biological and Chemical (NBC) warfare defenses, Title XVII of the National Defense Authorization Act for Fiscal Year 1994 (Public Law 103-160) required the Department of Defense (DoD) to consolidate management and oversight of the Chemical and Biological Defense (CBD) program into a single office within the Office of the Secretary of Defense. The public law also directed the Secretary of Defense designate the Army as the Executive Agent for coordination and integration of the CBD program. The executive agent for the SBIR portion of the program is the Army Research Office-Washington (ARO-W).

The objective of the DoD CBD program is to enable U.S. forces to survive, fight and win in chemical and biological warfare environments. Numerous rapidly-changing factors continually influence the program and its management. These forces include declining DoD resources, planning for warfighting support to numerous regional threat contingencies, the evolving geopolitical environment resulting from the breakup of the Soviet Union, U.S. participation in the Chemical Weapons Convention, and the continuing global proliferation of chemical and biological weapons. Improved defensive capabilities are essential in order to minimize the impact of the use of such weapons. U.S. forces require aggressive, realistic training and the finest equipment available that allows them to avoid contamination, if possible, and to protect, decontaminate and sustain operations throughout the non-linear battlespace. Further information about the DoD CBD Program (and related programs) is available at the DoD Counterproliferation and Chemical Biological Defense Homepage at Internet address http://www.acq.osd.mil/cp/.

The overall objective of the CBD SBIR program is to improve the transition or transfer of innovative CBD technologies between DoD components and the private sector for mutual benefit. The CBD program includes those technology efforts that maximize a strong defensive posture in a biological or chemical environment using passive and active means as deterrents. These technologies include chemical and biological detection; information assessment, which includes identification, modeling and intelligence; contamination avoidance; and protection of both individual warfighters and equipment.

Tri-Service Program

The U.S. Army, Navy, and Air Force have developed separate SBIR topics for research and development in various CBD areas of interest. As lead agency, the Army will coordinate Tri-Service efforts related to the receipt, evaluation, selection, and award of Phase I proposals and similarly for potential follow-on Phase II efforts under this program.

Topic Submission

All proposals submitted in response to CBD topics must be mailed to the address provided below. Potential offerors must follow the proposal submission rules for the agency which has proponency for topics. Topics are numbered in series, with Army topics starting at 101, Navy topics starting at 201, and Air Force topics starting at 301. Detailed instructions for proposals to be submitted against Army topics are given below. **Refer to the appropriate Navy and Air Force sections in this Solicitation for information on how to prepare proposals for submission against Navy and Air Force CBD topics.**

Notice for Navy proposers: The Army Research Office-Washington is not equipped to handle online (Internet or e-mail) proposal or Appendix A & B submissions. For all Navy proposals, an original and four copies must be submitted to the address provided below. Supplementary diskettes required by the Navy will also be accepted.

Army Proposal Guidelines

The Army has enhanced its Phase I-Phase II transition process by implementing the use of a Phase I Option that the Army may exercise to fund interim Phase II activities while a Phase II contract is being negotiated. The maximum dollar amount for a Phase I feasibility study is $70,000. The Phase I Option, which **must** be proposed as part of the Phase I proposal, covers activities over a period of up to four months and at a cost not to exceed $50,000. All proposed Phase I Options must be fully costed and should describe appropriate initial Phase II activities which would lead, in the event of a Phase II award, to the successful demonstration of a product or technology. **The Army will not accept Phase I proposals which exceed $70,000 for**

the Phase I effort and $50,000 for the Phase I Option effort. Only those Phase I efforts selected for Phase II awards through the Army's competitive process will be eligible for exercise of the Phase I Option. To maintain the total cost for SBIR Phase I and Phase II activities at a limit of $850,000, the total funding amount available for Phase II activities under a resulting Phase II contract will be $730,000.

Companies submitting a Phase I proposal to the Army under this Solicitation must complete the Cost Proposal, Appendix C, within a total cost of $70,000 (plus up to $50,000 for the Phase I Option). Phase I and Phase I Option costs must be shown separately; however, they may be presented side-by-side on a single Appendix C. The Phase I Option proposal must be included within the 25-page limit for the Phase I proposal. In addition, all offerors will prepare an Appendix E, Company Commercialization Report, for each proposal submitted. Appendix E does not count toward the 25-page limitation.

Selection of Phase I proposals will be based upon scientific and technical merit, according to the evaluation procedures and criteria discussed in this solicitation document. Due to limited funding, the Army reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality will be funded.

Proposals not conforming to the terms of this solicitation and unsolicited proposals will not be considered. Awards will be contingent on availability of funding and successful completion of contract negotiations.

Army Phase II Proposal Guidelines

Phase II proposals are invited by the Army from Phase I projects that have demonstrated the potential for commercialization of useful products and services. The invitation will be issued by the Army organization responsible for the Phase I effort. Invited proposers are required to develop and submit a commercialization plan describing feasible approaches for marketing the developed technology. Fast Track participants may submit a proposal without being invited. Cost-sharing arrangements in support of Phase II projects and any future commercialization efforts are strongly encouraged, as are matching funds from independent third-party investors, per the SBIR Fast Track program (see section 4.5). Commercialization plans, cost-sharing provisions, and matching funds from investors will be considered in the evaluation and selection process, and Fast Track proposals will be evaluated under the Fast Track standard discussed in section 4.3. Phase II proposers are required to submit a budget for a base year (first 12 months) and an option year. These costs must be submitted using Appendix C, Cost Proposal, and may be presented side-by-side on a single Cost Proposal Sheet. The total proposed amount should be indicated on Appendix A, Proposed Cost. Phase II projects will be evaluated after the base year prior to extending funding for the option year.

The Army is committed to minimizing the funding gap between Phase I and Phase II activities. With the implementation of Phase I Options all Army Phase II proposals will receive expedited reviews and be eligible for interim funding. Accordingly, all Army Phase II proposals, including Fast Track submissions, will be evaluated within a single evaluation schedule.

Mailing Address for all CBD Proposals

**Offerors using non-government courier services assume the risk for late delivery of proposals.*

Dr. Kenneth A. Bannister
U. S. Army Research Office - Washington
Room 8N23
5001 Eisenhower Avenue
Alexandria, VA 22333-0001
Telephone: (703) 617-7425

Key Dates

99.1 Solicitation Open	1 December 1998 – 13 January 1999
Phase I Evaluations	January - April 1999
Phase I Selections	April 1999
Phase I Awards	May 1999

PROPOSAL CHECKLIST

This checklist is provided to assist in preparing your proposal for submission. Please review the checklist carefully to assure that you proposal meets the SBIR requirements. Failure to meet these requirements may result in your proposal being returned without consideration. Do not include this checklist with your proposal.

_____1. The proposal budget adheres to the individual Service criteria specified.

_____2. The proposal is limited to only one solicitation topic.

_____3. The proposal (plus the Phase I Option for Army topics only) is 25 pages or less in length. (Excluding company commercialization report.) Proposals in excess of this length will not be considered for review or award.

_____4. The Cover Sheet (Appendix A) has been completed and is PAGE 1 of the proposal

_____5. The Project Summary Sheet (Appendix B) has been completed and is PAGE 2 of the proposal.

_____6. The Technical Content of the proposal begins on PAGE 3 and includes the items identified in Section 3.4 of the solicitation.

_____7. The Technical Abstract contains no proprietary information, does not exceed 200 words, and is limited to the space provided on the Project Summary Sheet (Appendix B).

_____8. The proposal contains only pages of 8 1/2 x 11 size. No other attachments such as disks, video tapes, etc. are included.

_____9. The proposal contains no type smaller than 11 point font size (except as legend on reduced drawings, but not tables).

_____10. The Contract Pricing Proposal (Appendix C) is complete, is signed with an original signature, and is included as the last section of the proposal. (For Army topics the **Phase I and Phase I Option** costs must be shown separately on Appendix C).

_____11. The final proposal is stapled in the upper-left-hand corner, and no special binding or covers are used.

_____12. An original and four copies of the proposal are submitted.

_____13. The Company Commercialization Report, (Appendix E) in accordance with Section 3.4.n. is included. (This report does not count towards the 25 page limit)

_____14. Include a self-addressed stamped envelope and a copy of the Notification Form, Reference A, located in the back of the solicitation book, if notification of proposal receipt is desired. **No responses will be provided if these are not included with your proposal.**

_____15. The proposal must be sent registered or certified mail postmarked by the date specified in Section 6.2, or delivered to the Army SBIR Office no later than **January 13, 1999, 2:00 p.m. local time** as required.

INDEX OF CHEMICAL BIOLOGICAL DEFENSE FY99 TOPICS

CHEMICAL BIOLOGICAL DEFENSE FY99 TOPICS

CBD99-101 TITLE: Computational Fluid Dynamic Modeling of Agent Transport Through Protective Clothing Systems

TECHNOLOGY AREA: Chemical And Biological Defense

OBJECTIVE: Develop a computational fluid dynamic (CFD) model of a clothed human, which can be used for studies of the various transport phenomena affecting the thermal balance of soldiers wearing chemical protective uniforms under different environmental conditions, while at the same time accounting for the transport of chemical agents through the clothing system in vapor or liquid form.

DESCRIPTION: The geometric configuration of a protective clothing system (fit, air spaces, closures, and seals) may be just as important as clothing layer material properties to the total performance of the clothing system. Recent advances in CFD codes (unstructured grids, block/adaptive/moving grids), as well as in computational hardware (speed/memory), make it possible to create accurate engineering CFD models which can include the irregular shapes of a clothed human, as well as the extremely different length and time scales present in a typical computation (i.e. extremely thin clothing layers over a relatively large human body and irregular air spaces). Modern chemical protective garments provide high levels of protection against battlefield chemical threats, yet are often found to impose high levels of heat stress under certain environmental conditions. Transport through the clothing system involves diffusion of heat and moisture, convective air flows, and liquid water capillary wicking. Hygroscopic fibers may absorb water in vapor or liquid form and release the heat of sorption, which serves as an energy source within the clothing. Depending on the ambient environment, water vapor may condense in outer layers of clothing, which liberates the heat of condensation and serves as another heat source within the clothing. Many modern protective clothing systems also include polymeric membranes, which may be either a microporous hydrophobic polymer (e.g. polytetrafluoroethylene), or a very thin solid layer of a hydrophilic polymer (e.g. polyurethane). The various steps involved in sorption of liquid water or vapor into the membrane, diffusion through the structure, and desorption from the other side, are often complicated by the concentration-dependent permeation properties of many of the polymers in common use. All of these processes are time-dependent. Particularly for the hygroscopic materials, equilibrium does not take place within a matter of seconds, but may require time scales of minutes to hours. Since humans are rarely working at a sustained constant work level for hours on end, steady-state approximations to determine quantities such as total moisture accumulation within the clothing, total heat and mass transferred through the clothing, are often inaccurate since the steady-state heat and mass transfer properties are inapplicable. This project is aimed at providing a useful analysis tool for studies of the various transport phenomena affecting the thermal balance of soldiers wearing chemical protective uniforms under different environmental conditions, while at the same time accounting for the transport of chemical agents through the clothing system in vapor or liquid form. It addresses the current need for more realistic models of coupled heat and mass transfer through textile-based chemical protective materials which include phenomena such as liquid water wicking, condensation/evaporation within textile layers, concentration-dependent permeation behavior of semipermeable membrane laminates, phase change materials incorporated into clothing components, sorption behavior of hygroscopic textile fibers, and incorporating multicomponent transport, to account for effects associated with diffusion/ convection/sorption of organic vapor/liquids in addition to effects associated with the coupled transport of heat and moisture.

PHASE I: Application of a general CFD code to systems and geometries of interest in chemical protective clothing systems; i.e. modeling the correct geometry of a clothed soldier, including clothing air spaces and fabric properties, subjected to a given set of environmental conditions and chemical vapor challenges. The Phase I work will model a static clothed human form subject to convection/diffusion processes for heat and vapor/gas transport, with the clothing layers participating in vapor phase sorption phenomena only (liquid phenomena of wicking/evaporation/condensation would be deferred to Phase II).

PHASE II: Extension of the basic CFD model to incorporate moving grid capabilities to follow body and clothing movement ("pumping" effects). Account for more complicated transport phenomena such as aerosol transport and deposition, liquid wicking/evaporation/ condensation, general phase change phenomena such as sorption/desorption.

COMMERCIAL POTENTIAL: A usable CFD model of a clothed human will be useful for applications such as industrial chemical protective suits, comfortable sportswear, and industrial design of heating and ventilation systems for workspaces and transportation systems.

REFERENCES:

1. Gibson, P., Charmchi, M., "Coupled Heat and Mass Transfer Through Hygroscopic Porous Materials -- Application to Clothing Layers," Journal of the Society of Fiber Science and Technology, Japan (Sen-i Gakkaishi) 53, No. 5, May, 1997.

2. Gibson, P. Charmchi, M., "Integration of a Human Thermal Physiology Control Model with a Numerical Model for Coupled Heat and Mass Transfer Through Hygroscopic Porous Textiles," Paper No. 96-WA/HT-29 (reprint available from American

Society of Mechanical Engineers), Heat Transfer Session HT-10, 1996 International Mechanical Engineering Congress and Exposition , Atlanta, Georgia, November 17-22, 1996.

CBD99-102 TITLE: High-Speed, Rugged Tuner for Low Cost, Standoff Chemical and Biological Detection

TECHNOLOGY AREA: Chemical And Biological Defense

OBJECTIVE: Develop a high-speed, rugged tuning device to obtain enhanced selectivity and sensitivity of chemical and biological (CB) agent identification in a low cost standoff detector. This topic does not duplicate any topic in any other SBIR/STTR solicitation.

DESCRIPTION: This topic solicits innovative and creative solutions to a research and development (R&D) problem in achieving high-speed tuning. This project will establish the technical feasibility of producing a high-speed tuner for DoD LIght Detection And Ranging (LIDAR) standoff CB detectors for contamination avoidance and decontamination, and for identification of weapons of mass destruction (WMD) manufacturing. All innovative approaches are encouraged and will be considered, provided they meet Phase I and II technical goals.

As stated in the definition of the Joint Warfighting Capability Objective (JWCO) for CB Warfare Detection, the "Capability for standoff detection of biological and chemical agents is our single most pressing need." Also, the one of the 2 Counterproliferation JWCOs is stated as the "Capability to detect and evaluate the existence of a manufacturing capability for weapons of mass destruction (WMD)." Standoff CB detectors are under development within DoD to address these objectives, such as the Joint Service Warning and Identification LIDAR Detector (JSWILD), which is supported by the Laser Standoff Chemical Detection Defense Technology Objective (DTO). One of the most critical components of these detectors is the wavelength tuner.

Current LIDARs for standoff CB detection uniquely identify CB agent spectral features by utilizing wavelength tuners that are mechanical in nature. For example, the carbon dioxide (CO2) LIDAR uses a rotating polygon or galvanometer (see references 1 and 2) to move a mirror that images a fixed grating. This device is capable of switching wavelengths at rates of up to 200 Hz. However, it is susceptible to temperature and vibration shifts unless extraordinary measures are taken to minimize these effects. Even these measures are only marginally effective and they are quite costly as they raise the price of the unit by an order of magnitude. Thus, a rugged tuner is needed.

Recent technological advances allow utilizing the non-linear properties of electro-optic crystals to construct a high-speed (up to 10 kHz) solid-state electronic tuner. Because of the lack of moving mechanical parts, it could be completely immune from shock and vibration, much less costly, and more accurate, therefore providing greater reliability, selectivity, and sensitivity. Also, when used with high-speed solid-state lasers, it would be possible to scan very large regions of spectra in a search mode and identify areas of CB agent contamination in a fraction of a second. In addition, recent developments in solid-state lasers make it possible to construct highly efficient, high repetition rate transmitters that utilize less diodes for pumping the laser medium. Since diodes are a major portion of the cost of the laser, this quasi-CW pumping will lead to substantial cost reduction of standoff CB detectors. However, the current mechanical tuners cannot tune rapidly enough to take advantage of this approach. Thus, a high-speed tuner is needed.

Development of such a tuner directly supports both short-range (JSWILD) and long-range (Miniature Standoff Agent Detector) goals for Contamination Avoidance identified in the Joint Service Nuclear, Biological, and Chemical (NBC) Defense Research, Development, and Acquisition (RDA) Plan, and outlined in its Chemical Detection Roadmap. These standoff detectors also support Joint Service goals in Wide Area Decontamination by identifying and mapping areas of contamination. There is a very high commercialization potential for this technology, since the device will be capable of high-speed scanning in addition to high-speed tuning. High-speed scanners are used in a multitude of commercial electronic devices.

PHASE I: Laboratory demonstration of an all solid-state tuning device. The ability to tune an Optical Parametric Oscillator (OPO) shifted laser shall be demonstrated. The nominal wavelength tuning range shall be within the 3-5 micrometer band (8-12 um goal) and the tuning rate shall be at least 2 kHz.

PHASE II: The wavelength tuning range shall be extended to include the 8-12 micrometer band. At least 4 mJ shall be obtained within the 3-5 micrometer range and at least 0.2 mJ shall be obtained within the 8-12 micrometer range. The tuning device shall occupy a volume less than the current galvanometric tuner (0.05 cubic feet). It shall demonstrate immunity to temperature changes over the +40 to - 40 degree C range. Laser tuning shall remain accurate during the temperature tests so that at least 90% of the maximum energy is still available.

COMMERCIAL POTENTIAL: Phase III military applications include full-sized and miniature standoff CB detectors for contamination avoidance, decontamination, and counterproliferation. Other Phase III military applications include electro-optical systems requiring a high-speed tuning or scanning device, such as optical countermeasures, rangefinders, and designators. Phase III commercial applications include detectors for standoff environmental pollution monitoring. Other Phase III commercial applications include electro-optical systems requiring a high-speed tuning or scanning device, such as bar code and laser light scanners. Hence, a COTS device is envisioned for insertion into future military systems.

REFERENCES:
1. Fox, J. and Ahl, J., "High speed tuning mechanism for CO2 lidar systems," Applied Optics, Vol. 25, No. 21, pp. 3830-3834, Nov 1, 1986.

2. Gautier, C. and Fox, J., "Evaluation of a galvanometric scanner for rapid tuning of CO2 lasers," Review of Scientific Instruments 60 (3), pp. 322-326, March 1989.

CBD99-103 TITLE: Modular Microfluidic Packaging

TECHNOLOGY AREA: Chemical And Biological Defense

OBJECTIVE: Development of modular microfluidic systems for interfacing MEMS sensors with the macroscopic environment

DESCRIPTION: Microfabrication and MEMS technologies have enabled a new physical domain for microanalytical systems: the microfluidic domain. There has recently been considerable interest and funding of programs to build miniaturized chemical analysis and synthesis systems on a single chip, reminiscent of the integration of microelectronic devices into ICs. A fundamental problem still exists, however, which is interfacing these systems to the external, macroscopic world. Many new microfluidic devices are being developed, but their insertion into systems will remain limited by packaging difficulties, fluidic pumping, and the integration of disparate technologies into a single system. Much development is needed in the area of packaging of microfluidic systems as well as modular approaches which allow devices and subsystems from differing technologies to be integrated into compact systems. Developmental research in this area would include miniaturized fluid connector systems, sealing and pumping technologies, and breadboard approaches which allow different technologies to be assembled into systems without the use of small tubing. Such approaches might include fluidic analogs to a printed-wiring board, or lego-like building blocks which have standardized fluid ports. The development of any standards in this area would greatly accelerate the insertion of new microfluidic devices and analytical protocols into commercializable systems.

PHASE I: Current microfluidic systems will be cataloged and investigated and an evaluation of packaging and interface requirements will be made. From this investigation, modular approaches will be designed for the integration of various microfabricated sensor units into complete systems. One or more MEMS sensor devices will be selected for Phase II microfluidic integration.

PHASE II: A modular microfluidic system will be constructed and demonstrated. Integration with the MEMS sensor device(s) selected in Phase I will conducted for development of a complete biosensor system ready for field tests. Initial packaging and interface standards will be presented for possible incorporation into ASME or MIL standards.

COMMERCIAL POTENTIAL: Development of packaging and interface standards would greatly accelerate the insertion of new microfluidic devices and analytical protocols into commercializable systems. Such development would provide excellent infrastructure for many new product areas and would service a growing and lucrative product market.

KEYWORDS: Microfluidics, MEMS, biosemsors, modular interfaces

CBD99-104 TITLE: Nanoscale Electrochemical Biosensors

TECHNOLOGY AREA: Chemical And Biological Defense

OBJECTIVE: Development of nanoscale microelectrodes (nanoelectrodes) for integration into on-chip electrochemical microanalytical biosensor systems. Development of nanoscale microelectrodes (nanoelectrodes) for integration into on-chip electrochemical microanalytical biosensor systems.

DESCRIPTION: Electrochemical techniques are particularly attractive for miniaturized chemical sensor systems which must have a closely coupled electronic interface. Redox chemistry which can be driven through microelectrodes enables numerous analytical techniques to be performed. Such techniques can provide qualitative and quantitative information about the sample media due to the direct relationship between electric current and surface reaction rate and the direct correlation between electrode potential and redox potentials of the analytes. Numerous advantages are obtained by making the electrodes smaller: faster equilibration with the solution, smaller capacitance, higher packing density, and the ability to be integrated into on-chip microanalytical systems. Thus far, most microelectrodes have been on the order of a few tens of microns for both integrated arrays and single probes, and the selectivity of the analysis technique has been limited to the natural redox potentials of the analytes of interest, for example, heavy transition metals, organo-nitrate and organo-phosphorous compounds, and a few ionizable organic ligands. Much promise exists for pushing both of these present boundaries: decreasing the size of the electrodes and altering the redox potentials with modifier compounds. Producing arrays of electrodes with dimensions

substantially less than one micron will allow kinetic as well as compositional information to be obtained due to the increased response time of the electrode and its solution interface. Greatly improved chemical selectivity can be obtained by tagging high-selectivity antibodies or antigens with redox-modifying tags that can be readily distinguished through voltammetric scanning techniques. Similar selectivity can also be obtained through the use of functionalized surface coatings on the microelectrodes which limit the binding and redox characteristics of specific molecules. The development of these techniques will require existing expertise in electrochemical analytical techniques and microfabrication, along with necessary infrastructure for nanoscale device fabrication and molecular surface and ligand engineering.

PHASE I: The ability to fabricate nanoscale electrodes will be demonstrated. Units will be constructed which are considerably smaller than current microelectrodes (these are typically a few tens of microns) and demonstrated on a laboratory breadboard. Protocols for the use of redox-modifying tags with antibody-antigen systems will be developed.

PHASE II: A prototype system will be developed which employs arrays of nanoelectrode sensing elements coupled to an immunoassay for detection of chemical or biological threat agents. The prototype system will be small, rugged, highly portable and suitable for field testing. A plan for the manufacture of these biosensors into portable handheld units will also be developed.

COMMERCIAL POTENTIAL: These technologies build upon recently developed scientific knowledge of microelectrode and nanoelectrode behavior, and would be directly applicable for many DoD-related problems, including battlefield personnel and environment monitoring, clinical healthcare applications, industrial chemical and pharmaceutical development and quality control, and agricultural and metropolitan pathogen detection.

KEYWORDS: Nanoelectrodes, MEMS, redox, microfabrication, biosensors, immunoassay

CBD99-105 TITLE: Synthesis of HD-Related Hapten-Protein Conjugates

TECHNOLOGY AREA: Biomedical

OBJECTIVE: To acquire the materials necessary for the production of monoclonal antibodies useful for the development of a non-invasive immunodiagnostic test for exposure to sulfur mustard.

DESCRIPTION: Research plans for a monoclonal antibody based enzyme immunoassay to detect exposure to sulfur mustard require the custom synthesis of haptenic protein conjugates that can be used both as mouse immunogens to generate hybridomas and as solid phase antigens for immunoassay development. Our proposed analytical system makes use of the unique structure of the major mammalian urinary metabolite of sulfur mustard to detect and document exposure.

PHASE I: The required materials consist of two analogs of the symmetrical dimercapturic acid metabolite of sulfur mustard bis[(2-acetylamino-2-carboxyethylthio)ethyl] sulfone. The haptenic compounds would have to be modified to allow conjugation to each of two proteins. One of these haptens must be attached to the carrier proteins through the central sulfur atom. The other can be conjugated through one of the terminal carboxyl or amino groups. The carrier proteins in each case would be either KLH or porcine thyroglobulin and BSA. The molar ratio of hapten to protein in the final products must be quantitatively determined. The final preparation must be stable and form a homogeneous solution when dissolved in buffer at physiologic pH. 500 mg of each conjugate in freeze dried form is required.

PHASE II: Larger scale production (20-30 g lot) of the appropriate test antigens or other test compounds for preliminary development of the immunoassay.

COMMERCIAL POTENTIAL: The joint development of an immunoassay based test device to use in HD immunodiagnostics and forensic analysis in a battlefield or terrorist situation CDC, Other governments, state and local emergency Authorities.

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KEYWORDS: Sulfur Mustard, Immunodiagnostics, forensics

CBD99-106 TITLE: Evaluation of Immune Response and Development of Improvements for Naked DNA Vaccines

TECHNOLOGY AREA: Biomedical

OBJECTIVE: Improvements to naked DNA vaccine delivery systems

DESCRIPTION: Vaccines that are administered in the form of "naked DNA" encoding immunogens of interest hold great promise for human use. Naked DNA vaccines are being evaluated for a variety of infectious disease agents and biological defense agents. This approach offers numerous advantages, such as the potential to immunize an individual against multiple immunogens simultaneously, the use of a common platform for vaccines against multiple agents, the lack of a requirement to grow pathogenic organisms for vaccine preparation, the the possibility of targeting specific immunological responses. The mechanisms for delivering such DNA, delivered typically as plasmids, have focused on direct intramuscular inoculation of the preparation, or by particle bombardment approaches where microscopic gold beads, coated with the DNA plasmids, are projected directly into the skin epithelial cells by electrostatic discharge of helium. Additional techniques to enhance DNA delivery to target cells involves placing the DNA molecules into a carrier system, such as a nanosphere or a liposome. The chief requirements for any delivery system of naked DDNA is that potency be maximized relative to the immunizing dose, and that the appropriate immune system response be stimulated leading to protective efficacy. A final consideration for improvement to naked DNA vaccine candidates is that the product be safe for human use.

PHASE I: Evaluate the naked DNA immune response to a specific biological threat agent, or infectious disease agent; e.g., vector-borne viruses, bacterial agents (plague, anthrax, brucella), or viral agents (alpha viruses, filo viruses, orthopox viruses). Develop alternative naked DNA vaccine delivery mechanism(s) that will lead to either enhanced protective humoral antibody production or to increased cellular immune response. Demonstrate the improvement in an appropriate challenge model. Improvement can be assessed for a variety of parameters, but most importantly, would be prioritized as 1) demonstration of greater than or equal to 90% protective efficacy, 2) acceleration (50%) in the time required to protective immunity, 3) increased duration (50%) of protective efficacy, or 4) broader spectrum of immunological response (e.g., cross-protective response across strains or species of pathogens). Evaluate animal safety of the alternative delivery system for eventual human use.

PHASE II: Develop scale up production procedures for the improved delivery system. Further characterize the immunological response. It is envisioned that a successful outcome would be a new method for enhancing immune response to a particular agent chosen as a model system by the SBIR applicant, e.g., a new procedure for delivering DNA, or incorporation of immunostimulatory sequences or co-factors encoded in the vaccine construct, etc. Should such a method prove promising for the target agent, the deliverable would include the developed vaccine construct as well as the information on an improved methodology for potential application with other agents of interest.

COMMERCIAL POTENTIAL: Naked DNA vaccine technology is an area of active investigation in the biologics industry for a variety of endemic bacterial, viral and protozoal disease threats. Evaluation of immunological responses to naked DNA vaccines leading to improvements in the design and delivery of such vaccines would have tremendous application in the commercial sector biologics industry. Development of effective and safe naked DNA vaccines for use by military populations would potentially realize logistical and cost savings by reducing the number of immunizations required in combination vaccines for multiple agents by using the naked DNA approach as a single delivery platform, and from development and manufacturing savings as a result of the greater degree of characterization of naked DNA vaccines and lowered risk relative to methods requiring production and storage of live agents.

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KEYWORDS: Naked DNA Vaccine Immune Response Immunogens Nanosphere Liposome

CBD99-107 TITLE: Therapeutic intervention for control and prevention of pathologies associated with staphylococcal enterotoxins and pyrogenic streptococcal exotoxins

TECHNOLOGY AREA: Biomedical

OBJECTIVE: Develop pharmaceutical or biological products (nonvaccine) that will alleviate or prevent toxicologies or malaise caused by exposure to staphylococcal enterotoxins, streptococcal pyrogenic exotoxins and related exotoxins. Priority is given to proposals that have reasonable translational potential.

DESCRIPTION: Enterotoxins and pyrogenic exotoxins are virulence factors produced by Staphylococcus aureus and group A streptococci. The enterotoxins can cause acute, gastrointestinal disorders and a life-threatening toxic-shock syndrome may accompany parenteral exposure to any of these toxins. Current concepts suggest that toxicity is mediated by the release of pathological levels of proinflammatory cytokines, initiated by an overwhelming stimulation of the immune system. Proposals are solicited to provide new or previously existing pharmaceutical and biological products as prophylactic or therapeutic agents for the control of pathologies associated with these toxins. These agents may be used in combination with or as substitutes for vaccines. In addition, novel pharmacological substances that are useful for treating symptoms of toxin exposure, such as nausea and disorientation are also requested.

PHASE I: Demonstrate feasibility of specific pharmaceutical or biological products to control or prevent toxicities from exposure to staphylococcal enterotoxins and pyrogenic streptococcal exotoxins in ex vivo, in vitro, or experimental animal models.

PHASE II: Demonstrate efficacy of specific pharmaceutical or biological products to prevent toxic-shock syndrome in nonhuman primates or to alleviate pathological symptoms.

COMMERCIAL POTENTIAL: A high frequency of toxigenic S. aureus and group A streptococci strains colonize the human population. Toxic shock syndrome has emerged as a significant health threat to the general population and may be associated with respiratory infections, surgical or nonsurgical wounds, and a variety of other infections. Any successful treatment resulting from this effort will be useful for treatment or prophylaxis of toxic-shock syndrome within the public sector. Therapeutic interventions are needed for treatment of military personnel exposed to these toxins by: 1) infections of surgical or nonsurgical wounds, including combat injuries, 2) direct respiratory, dermal or mucosal infections, 3) secondary diseases of viral infections, 4) deliberate exposure from use as biological warfare agents.

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KEYWORDS: Pathologies, nonvaccine, staphylococcal, enterotoxins, pyrogenic, exotoxins, Therapeutic intervention, Prevention, Toxicologies, malaise, toxigenic S., proinflammatory cytokines, aureus, toxigenic, nonsurgical

CBD99-201 TITLE: Integrated Microfluidics And Optics For Miniature Biosensors

TECHNOLOGY AREA: Sensors

OBJECTIVE: Design and fabricate a handheld sensor including automated fluidics and optics for interrogating a sensing chip coated with an array of detector antibodies.

DESCRIPTION: Antibodies can be immobilized on a variety of glass and plastic surfaces in geometrically defined arrays. In a manually operated system, these arrays have been interrogated using evanescent illumination and a CCD for readout with detection of BW agents at the ng/ml level. The prototype used for such studies used a diode laser for excitation and simple microscope slides as waveguides. Simple, disposable components for sensors are required that include arrays of immobilized antibodies as sensing surfaces, fluidics for handling sub-ml volumes, and integrated optical components for signal generation. This disposable component should interface with a portable device containing the light source and detector, permanent fluidics components, and data readout electronics. The fluidics should be appropriate for handling complex sample matrices such as blood and groundwater.

PHASEI: Design sensing system and demonstrate performance of disposable component.

PHASE II: Fabricate device prototype integrating fluidics, optics, and data processing software and demonstrate assay sensitivity, speed, and reproducibility.

PHASE III: Design and fabricate a manufacturable prototypes of device and disposable components..

COMMERCIAL POTENTIAL: Such a sensor would provide on site testing capability for simultaneous analysis of multiple analytes. Applications in addition to the detection of biological warfare agents include pollution monitoring, infectious disease diagnosis, process monitoring, and detection of drugs of abuse.

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KEYWORDS: biosensor, microfluidics, integrated optics, multianalyte sensing

CBD99-202 TITLE: Advanced Materials/Processes for High Efficiency Particulate Air (HEPA) Filtration.

TECHNOLOGY AREA: Chemical And Biological Defense

OBJECTIVE: Investigate the acceptability/availability of materials and/or processes that offer significant improvements over the current collective/individual protection particulate filtration technology (i.e. High Efficiency Particulate Air (HEPA) filter).

DESCRIPTION: The current technology used to filter Nuclear, Biological, and Chemical particulates and aerosols, for individual and collective protection filtration systems, is a HEPA filter. The current HEPA technology consists of a glass fiber filter that traps NBC aerosols and particulates at an efficiency of 99.97% for a 0.3 micron particle. While effective, the current HEPA media has the following burdens: (1) induces a significant pressure drop, (2) inability to be effectively and easily

cleaned, (3) insufficient particle loading capacity (4) excessive cost of manufacture. It is highly desirable to identify a new particulate removal material and/or process, which improves the current HEPA filters performance while maintaining its collection efficiency and passive nature (i.e., does not require any power to function). A highly desired criteria is to substantially lower the pressure drop across the HEPA filter. The current HEPA filter media used in NBC collective protection filters imposes a substantial pressure drop across NBC filtration systems. This pressure drop forces motor blowers to demand more power from batteries and/or power generators to move air through an NBC filter. If the pressure drop across the HEPA filter were reduced the power savings from the NBC system could then be used to power other mission essential equipment, such as, auxiliary generators and computers.

PHASE I: Conduct preliminary laboratory testing and analysis, and provide an evaluation of the proposed material/process feasibility for eventual Joint Service use and probability of success to the government.

PHASE II: Conduct additional sub-scale testing to confirm laboratory scale results and sizing design methodology. Fabricate full-scale prototype and test IAW MITL-STD-810E to confirm feasibility.

COMMERCIAL POTENTIAL: Prepare for technology transition to Demonstration/Validation phase. Contractor shall construct prototype filters using an existing military filter platform and test. Provide report and recommendations to the government. HEPA and ultra-low particulate air (ULPA) filters are currently used in "clean rooms" to construct microelectronics. A low pressure drop HEPA/ULPA filter will have great utility in commercial application by reducing power consumption and the overhead cost to manufacture microelectronics.

KEYWORDS: particulate; filtration; high-efficiency; aerosol; HEPA; ULPA

CBD99-203 TITLE: Enhanced Technology for Chemical and Biological (CB) Agent Resistant Flexible Composites

TECHNOLOGY AREA: Chemical And Biological Defense

OBJECTIVE: Advance the state-of-the-art of flexible composites that can be used in tentage to provide CB agent protection. Improved performance and reduced cost will result in increased availability of CB protected tentage across the battlefield.

DESCRIPTION: There is a documented multi-service need for collective protection systems that will sustain operations and provide rest and relief in a CB agent contaminated environment (reference Joint Operational Requirements Document for a Joint Transportable Collective Protection System). Limited flexible composite materials are currently available for CB tentage applications. Deficiencies of the existing materials include high cost, labor intensive manufacturing techniques, lack of durability, and inadequate flame resistance. The goal of this project is to address these issues by focusing on technology advancements in any of the following areas: new material composites, improved manufacturing processes, or simplified fabrication techniques.

PHASE I: Explore new materials, methods, or processes to optimize the performance and affordability of CB resistant flexible composites. Clearly demonstrate the advance(s) by fabricating and testing samples/prototypes

PHASE II: Refine the technology demonstrated in Phase I. Transition sub-scale systems to full-scale. Fabricate full-scale prototypes that demonstrate the new advancement and test to prove out concept.

COMMERCIAL POTENTIAL: Successfully demonstrated technology could be transitioned into the Joint Transportable Collective Protection System or existing CB tentage such as the Chemically and Biologically Protected Shelter or CB Protected DEPMEDS. Advances in protective fabrics can be transitioned into protective clothing used for toxic cleanup. Although there is not a widespread need for CB protective tentage in industry, commercial tent and awning manufacturers are interested in materials that have protective films that are highly durable and shed dirt. New CB protective materials that are inexpensive and easy to fabricate with could be transitioned to this commercial area.

KEYWORDS: chemical warfare; biological warfare; fabrics; tents; shelters; films

CBD99-204 TITLE: 3D Chem/Bio Response Trainer

TECHNOLOGY AREA: Manpower, Personnel And Training

OBJECTIVE: Create a 3D virtual world to train medical & support personnel in chem/bio Incident Response setup, flow management, and decontamination.

DESCRIPTION: Saving lives immediately after a chemical or biological incident requires quick and accurate action. 3D virtual world technology can be used to train medical & support personnel in the setup of the different chem/bio response stations and areas (triage, decontamination, stabilization, etc.). Details of the Hot Zone, Warm Zone & Cold Zone could be shown in the safety of a 3D world. This type of system could be programmed with specific tests to ensure the user learns the key points.

PHASE I: Identify the most applicable 3D virtual world development tool. Produce a paper design of a typical chem/bio incident response operation. Construct a prototype visualization. Work with the chem/bio experts to create a relevant set of scenarios, including shipboard/shore-based and CONUS/OCONUS. Identify types of tests to build into the system..

PHASE II: Develop 3D virtual worlds for each chem/bio scenario identified in Phase I. Include each station and component. Create hyperjumps to key locations in the world. Focus on critical tasks that must be performed to keep casualties alive. Illustrate the interactions expected with civilian first responders in CONUS scenarios. Develop and integrate the testing requirements from Phase I.

PHASE III: Modify the 3D virtual world, viewer, interface, and help files to provide training to other government agencies, medical students, EMS, fire and police.

COMMERCIAL POTENTIAL: This system could be used by emergency incident response departments in major urban centers, at major trauma centers, in medical schools, etc.

REFERENCES:

1. The DoD Defense Modeling and Simulation Office website at http://www.dmso.mil/ contains information about modeling and simulation standards and many other reference materials.
2. The Navy Modeling and Simulation Management Office (http://navmsmohq.navy.mil/) maintains a repository of Navy M&S programs and tools along with links.
3. The Naval Air Warfare Center Training Systems Division website contains descriptions of ongoing applications of 3D tools (http://www.ntsc.navy.mil/bf/scitech/appres.htm).
4. The Army Simulation, Training, and Instrumentation Command website (http://www.stricom.army.mil/) lists a variety Army uses of 3D tools in simulation and training.

KEYWORDS: Chem/Bio, Training, Decontamination, Triage, Incident Response

CBD99-205 TITLE: Air Deployed Chemical And Biologic Sensor

TECHNOLOGY AREA: Chemical And Biological Defense

OBJECTIVE: The proposed effort involves adapting sonobuoy delivery and monitoring technology to provide forward placement of sensors for early warning of CB (Chemical Biological) agents.

DESCRIPTION: The requirement to develop technologies for early warning of CB agents is well documented (Navy STRG, Joint Warfighter S&T Plan, etc.). Currently programs are in place to develop small inexpensive CB sensors for deployment with personnel. However, the capability to obtain stand-off detection through forward placement of point detectors through air drops (as suggested by the Joint Warfighter S&T Plan) is not currently under development. The program proposed is to adapt sonobuoy delivery and monitoring technology for delivery and monitoring of CB sensors. Information from these sensors would be integrated into the C4I systems by programs such as JWARN (Joint Warning And Reporting Network) which are already in progress. Deployment of these sensors could be used to support amphibious landings or to investigate the safety of vacated/destroyed enemy positions which might contain CB agents.

PHASE I: The Phase I effort will investigate the feasibility of using sonobuoy delivery and monitoring technology to provide forward placement of sensors for early warning of CB agents. This will involve determining the feasibility of packaging advanced CB and associated environmental sensors within sonobuoy packaging constraints and modifying the sonobuoy RF link to transmit CB and environmental data to monitoring naval aircraft.

PHASE II: The Phase II effort will involve the fabrication and test of functional, but not air deployable, prototype units. The form factor of these units will be consistent with sonobuoy packaging constraints. These units will be fully functional and capable of detecting, as a minimum, the chemical agents required by the JCAD (Joint Chemical Agent Detector) program. These units will be capable of linking the CB sensor and related environmental data to naval aircraft for remote monitoring.

COMMERCIAL POTENTIAL: The Phase III effort will involve the fabrication of air deployable units which meet all the functional requirements of the Phase II units. Sufficient quantities will be produced to fully qualify the design for deployment from naval aircraft. The technology to be developed under this SBIR could be easily adapted for monitoring CB hazards and spills in situations where manual sensor placement is too dangerous.

REFERENCES:
1. Operational Requirements Document For A Joint Chemical Agent Detector (JCAD)
2. Operational Requirements Document For A Joint Biological Remote Early Warning System (JBREWS)

KEYWORDS: chemical biologic sensors, sonobuoys

CBD99-301 TITLE: Modeling of Mask and Machine Interfaces for Mask Design Optimization

TECHNOLOGY AREA: Chemical And Biological Defense

OBJECTIVE: Develop a parametric respirator computer aided design (CAD) model that accounts for the interface of the mask design with operational equipment

DESCRIPTION: Current limitations in process, software tools, and separate product development environments require mask systems to be designed and fabricated from scratch to support product development, prototyping, field testing, redesign, manufacturing, and distribution. Considering that this process must occur independently for every size mask that is needed to fit the diverse facial characteristics of the military, the precision of these methods is less than adequate and the entire process is extremely expensive and time consuming. New methods need to be developed that both improve the mask development process and produce a mask with an optimal design. Recent efforts have been initiated to address specific segments of the mask design process. A working methods document of a parametric model of mask faceblank development for a prototype version of the Joint Service General Purpose Mask (JSGPM) has been developed to show the feasibility of parametrically designing the JSGPM faceblank. Also, efforts are in progress to model the effects of contact pressures between the face-seal of the mask and the fit of the mask for both comfort and protection and to model the effects of mask design on soldier performance. This effort would develop new technologies to develop a mask computer design model that has the capability to encompasses all segments of mask design and its compatibility with operational hardware. For example, the model would be able to predict the effects that altering a mask's lens size has on the interface of the mask with binoculars and weapons platform sighting systems. It could also predict compatibility of mask designs with communication equipment and individual warrior items such as rifles and helmets. Such a model would be able to track CAD changes and update mask component dimensions as needed to ensure optimization for compatibility with equipment interfaces for all mask faceblank sizes. The model would also provide visual as well as objective feedback to mask designers for analysis of design results.

PHASE I: Develop the concept of the system in block diagram form that includes both existing and new component technologies, their proposed interactions, their specifications, and the operation of the model. Demonstrate the operation of the model starting with a simplified mock-up of a mask, demonstrate additional modules for analysis of internal and external interfaces, perform gross design changes to the initial mock-up, and show model output.

PHASE II: Further develop and create a working model (including all new modules) to account for all mask design factors and hardware interfaces using supplied CAD specifics of existing and prototype masks. Conduct testing to validate the computer model and its components based on data for an established mask system.

COMMERCIAL POTENTIAL: This computer design model would have significant use in both industrial and medical applications where respiratory protection is required. It would enable the most cost-effective design of new respiratory protective equipment with optimal wearer and equipment interface for these applications. Also, this model would help for applications where off-the-shelf respirator selection is desired because users would be able to select a mask that meets their needs for both protection and interaction with their workplace hardware.

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KEYWORDS: computer aided design, respiratory protective equipment, equipment interface, weapon sighting systems, sighting devices, mask

CBD99-302 TITLE: Detection of Biological Agents and Pathogens in Water

TECHNOLOGY AREA: Chemical And Biological Defense

OBJECTIVE: To assure operational effectiveness and safety of personnel working in a toxic chemical/biological combat environment with respect to safe potable water quality

DESCRIPTION: A requirement was recently established for a chemical and biological water agent monitor. The development of a portable, field-deployable instrument that is capable of identifying waterborne biological agents and pathogens is needed. This effort seeks experience and capability that can be utilized to develop advanced technology for rapid and reliable detection of waterborne pathogens. It involves development of three sequential processes: (1) efficient recovery of microorganisms from source or finished drinking waters, (2) processing recovered microorganisms to allow effective detection, and (3) nucleic-acid based detection for accurate pathogen identification. These processes will ultimately be transitioned into the automated water monitor.

PHASE I: Phase I will involve devising a novel strategy for effective recovery and reliable detection of waterborne pathogens. The strategy will take into account current best available technologies and feasibility with respect to application to an automated field-deployable detection system.

PHASE II: Phase II will involve demonstrating the effectiveness of the selected technologies and approaches for meeting the requirements of the water monitor with respect to detection sensitivity and accuracy as well as potential application for the portable, field-deployable water monitor unit.

COMMERCIAL POTENTIAL: Phase III military applications include manportable detectors for contamination in potable water, decontamination/water treatment of contaminated potable water, contamination avoidance, counterproliferation (collateral effects), and force protection. Commercial applications include detectors for environmental pollution monitoring in municipal water facilities and public waterways.

KEYWORDS: water systems, pathogens, detectors, biological warfare agent, DNA, PCR, microorganisms

CBD99-303 TITLE: Standoff Biological Discrimination

TECHNOLOGY AREA: Chemical And Biological Defense

OBJECTIVE: Develop an eyesafe, non-UV-fluorescence, manportable, laser-based technique and system to discriminate biological agents at moderate standoff distances (5-10 km).

DESCRIPTION: Innovative and creative solutions to a research and development (R&D) problem in moderate range standoff biological agent detection are needed. Possible detection techniques include dual-wavelength (ratioed) scattering and multiple wavelength (Differential Scattering/Differential Absorption Lidar – DISC/DIAL) scattering and absorption as well as single-wavelength, multiple scattering (on- versus off-axis). All approaches are encouraged and will be considered, provided they meet Phase I and II technical goals. The current state-of-the-art biological detection system is a helicopter-mounted 1 micron scattering detection lidar with a planned upgrade to eyesafe and a range of 30-50 km with no capability to discriminate between naturally occurring aerosol clouds and those associated with a BW release. Another lidar, the Short-Range Biological Standoff Detection System, is currently being developed for evaluation. This device will be able to detect the presence of biologically-active particles within a naturally occurring aerosol environment but it utilizes non-eyesafe ultraviolet light, is severely limited in range, is quite large, and must be operated in darkness for maximum sensitivity.

Naturally occurring atmospheric particles fall into the 0.3 to 0.7 micron range. On the other hand, particles onto which BW agent have been deposited are much larger (2-10 microns). Thus, it is possible to discriminate clouds of BW agents by measuring the relative amounts of the backscattered signal compared to ambient conditions. For example, it has been shown that the relative amounts of light backscattering for BW agents at two wavelengths, 1.5 and 3.5 microns, differ from background backscattering by factors of 2 and 50, respectively. These figures depend strongly on the indices of refraction and whether or not the dispersals were wet or dry, but they show that the effect is quite measurable and could be used to perform the discrimination task. Recent spectroscopic and test data indicate that it may be possible to discriminate BW agents in the 9-11 micron region via DISC/DIAL methods. It has also been reported that spectroscopic data indicate the presence of absorption features within the 3-5 micron atmospheric window. Early indications are that perhaps the biological growth media and/or binders can be discriminated with lidars. It had previously been suspected that this may be the case, but until recently, there was no efficient laser sources that were tunable within that region until the maturation of optical parametric oscillator (OPO) wavelength shifting techniques. Thus, it now appears that the DISC/DIAL technique may be useful in the standoff discrimination of BW agents in two different wavelength regions. Preliminary calculations show that identification of the bio-aerosols could be possible at ranges up to 10 km if the DIAL technique proves viable. Finally, there is a well-established principle that larger (Bio) particles will more efficiently produce multiple scattered (off-axis) light than smaller (natural) aerosols at single, near-IR wavelengths (i.e. 1.5 microns), thereby affording another means of discrimination.

PHASE I: Past efforts in UV-fluorescence and typical light scattering have produced limited results. Recent test and spectroscopic data in the non-UV wavelength regions have been collected and thoroughly analyzed. Specifically, recent spectroscopic data will be obtained for the biosimulant bacillus globigii (BG). Other materials including known binders for BW agents have also been examined as well as the effect of growth media. These data will be used to specify the design

characteristics and project the performance of a moderate range (5-10 km) IR/NIR lidar using a novel bio-discrimination technique.

PHASE II: Construct a manportable lidar that will emit wavelengths shifted to eyesafe regions by optical parametric oscillation (OPO) or other techniques. The lidar will be used in field tests to demonstrate that the proposed novel technique can be used to identify BW simulants from naturally occurring aerosols at ranges of up to 5-10 km.

COMMERCIAL POTENTIAL: Phase III military applications include manportable, standoff CB detectors for contamination avoidance, decontamination, counterproliferation, and force protection. Phase III commercial applications include detectors for standoff environmental pollution monitoring.

KEYWORDS: standoff detection, LIDAR, biological warfare agent, laser, early warning

CBD99-304 TITLE: Water Distribution Simulator

TECHNOLOGY AREA: Chemical And Biological Defense

OBJECTIVE: Development of a water distribution simulator that can be used for the generation of contaminated water using chemical/biological hazardous materials to evaluate developmental and operational effectiveness of systems designed to detect toxic chemical/biological agents in combat environment with respect to safe potable water quality.

DESCRIPTION: A requirement was recently established for a chemical and biological agent water monitor. This requirement calls for a portable, field deployable instrument that is capable of detecting and identifying both chemical and biological agents. Currently, there is no standard methodology or generation equipment that can be used to challenge potential candidates for meeting the water monitor requirements. The development of the water distribution simulator is needed to provide the appropriate challenges (both chemical and biological materials) in respect to the following situations: (1) source water, batch mode water samples from streams, lakes, ponds, and other water sources that can be treated to provide potable water, (2) water quality verification, batch/continuous sampling at water treatment facilities or mobile reverse osmosis treatment unit to ensure the quality of potable water after treatment, and (3) integrity of water distribution systems, batch/continuous sampling of piping network (in-line main water pipe) within a fixed facility, storage containers, and consumer use points (i.e. shower points, water faucets, decontamination stations, etc).

PHASE I: Phase I will be dedicated to developing the standard methodology and test equipment system design to meet the challenges established by chemical and biological agent water monitor requirements.

PHASE II: Phase II will focus on fabrication and demonstration of the water distribution simulator. The system will be evaluated against a "standard" set of materials/conditions which will be provided by the government. System flexibility, stability and reproducibility will be of greatest importance.

COMMERCIAL POTENTIAL: Phase III military applications include test methodology/equipment for contamination in potable water, decontamination/water treatment of contaminated potable water, contamination avoidance, and counterproliferation (collateral effects). Commercial applications include test methodology/equipment for detectors in environmental pollution monitoring in municipal water facilities and public waterways

KEYWORDS: water systems, pathogens, detectors, biological warfare agent, microorganisms, chemical warfare agents, test equipment, test methodology

CBD99-305 TITLE: Chemical/Biological Decontamination System for Aircraft Cargo and Maintenance Equipment

TECHNOLOGY AREA: Chemical And Biological Defense

OBJECTIVE: Develop a deployable delivery system for application of chemical/biological (C/B) agent decontamination materials to aircraft cargo and maintenance equipment contaminated with C/B warfare agents.

DESCRIPTION: Current Air Force doctrine prohibits transportation of contaminated cargo and equipment off a contaminated base. As a result, contaminated cargo can not be delivered, contaminated maintenance equipment can not be deployed to where it's needed. This severely limits the Air Force's ability to accomplish the airlift and logistics support missions following C/B agent attacks. A deployable, cargo and equipment decontamination delivery system that can efficiently decontaminate contaminated cargo and equipment on the flightline at forward operation locations is required. Although multiple approaches may have merit. a system that employs decontamination materials as an aerosol under pressure in a flexible, closed environment

appears to offer considerable promise. The envisioned system must not damage the cargo or equipment, must be safe for system operators to use and must be compatible with current and future cargo handling and flightline maintenance procedures. The objective of this effort does not involve development of new decontamination materials, but rather focuses solely design and demonstration on the delivery system by which cargo/equipment decontamination can be achieved. This system may also serve as a means for decontaminating cargo/equipment that has been contaminated with industrial chemicals.

PHASE I: Define system requirements, evaluate feasibility of candidate systems and develop preliminary design for a deployable system for flightline decontamination of aircraft cargo and maintenance equipment contaminated with C/B warfare agents or industrial chemicals. Design must include a concept of operations (CONOPS) for how the system would be integrated with in AF airlift and logistics operations. The design trade studies must address system size, weight, deployability issues, power requirements, system maintenance requirements and development and operational cost as well as other pertinent factors.

PHASE II: Refine the preliminary design, develop a prototype system and demonstrate it's operational effectiveness by conducting decontamination trials using simulated agents.

COMMERCIAL POTENTIAL: The proposed system would be directly applicable to decontamination needs of the international commercial aviation market. Federal, state and local agencies the world over could benefit from this technology in the event of either accidental or intentional contamination with C/B warfare agents or exposure to industrial chemicals in legitimate use by industry

REFERENCES: http://www.acq.osd.mil/cp/nbc97.html

KEYWORDS: decontamination, cargo handling, aircraft maintenance, chemical/biological warfare agents, industrial chemicals, flightline, airlift, logistics

CBD99-306 TITLE: Decontamination Indicator for Chemical Warfare Agents

TECHNOLOGY AREA: Chemical And Biological Defense

OBJECTIVE: Development of a family of highly reactive compounds that produce intense chromophores in the presence of chemical warfare agents.

DESCRIPTION: The current methodology used in the decontamination of chemical warfare agents is labor, material, and time intensive. The concept of a decontamination indicator would reduce the burden on the need to decontaminate every piece of equipment and personnel from a suspected contaminated environment. The decontamination indicator would "highlight" the contamination and identify only the equipment or personnel that is actually contaminated for the decontamination process. A fully successful decontamination indicator should have the following properties: (1) produce a color change that is visible in standard field lighting conditions or under a commercial off the shelf "black light" (available from any hardware store or stores similar to Wal-Mart/Kmart/etc.) to the presence of 0.01 gram/m2 of contamination (2) increase in chromophore intensity with a maximum color change in the presence of 0.25 gram/m2 of contamination (3) color change occurs in less than one minute with a duration of at least one hour (4) application of indicator material not to exceed 0.01 gram/m2 of the active compound (5) percentage of active compound must be at least 0.05% in non-aqueous solvents or 0.005 percent in aqueous solvents (6) overall cost of indicator/solvent should not exceed $250 per gram of active indicator used and (7) must be fully materials compatible with all military equipment.

PHASE I: Phase I will be dedicated to the development/identification, characterization, and laboratory demonstration of the candidate indicator compounds and the conceptual design of the applicator system for applying the indicator. The primary focus will be on the indicator compounds with the applicator design secondary.

PHASE II: Phase II will focus on optimization, fabrication and demonstration of the overall system after the indicator has been demonstrated using surety materials. The indicator will be evaluated against a "standard" set of materials/conditions which will be provided by the government.

COMMERCIAL POTENTIAL: Phase III military applications include contamination avoidance and decontamination. Commercial applications include the capability to identify environmental contaminated equipment and areas for clean-up or remediation.

KEYWORDS: decontamination, chromophores, chemical warfare agents

NAVY
PROPOSAL SUBMISSION
INTRODUCTION

The responsibility for the implementation, administration and management of the Navy SBIR program is with the Office of Naval Research (ONR). The Navy SBIR Program Manager is Mr. Vincent D. Schaper ((703) 696-8528). The Deputy SBIR Program Manager is Mr. John Williams ((703) 696-0342). If you have any questions, problems following the submission directions, or inquiries of a general nature, contact one of the above persons. Phase I proposals must be received by **13 January 1999**. All Phase I proposals and subsequent Phase II Appendices A, B, and E must be submitted to:

Office of Naval Research
ATTN: NAVY SBIR PROGRAM, CODE 362
800 North Quincy Street, RM 633
Arlington, VA 22217-5660

The Navy's SBIR program is a mission-oriented program, which integrates the needs and requirements of the Navy through R&D topics which have dual-use potential. All Navy SBIR topics fall within the DOD Science and Technology areas and the Navy Science areas, listed in Table 1. Navy topics will be funded from these areas according to a priority it has established to meet its mission goals and responsibilities. Information on the Navy SBIR Program can be found at (**http://www.onr.navy.mil/sbir**). Additional information pertaining to the Department of Navy mission can be obtained by viewing various Navy World Wide Web sites at http://www.navy.mil

UNIQUE NAVY REQUIREMENTS:

1. Navy requires Appendix A, B and E to be submitted electronically through the Navy SBIR/STTR Website. The company must print out the forms directly from the Website, sign the forms and submit them with their proposal.
2. All Phase I award winners must electronically submit Phase I summary report through the website at the end of their Phase I.
3. Phase II award winners must also submit Phase II Summary Reports through this same websitet.
4. The Navy requires that all Phase II proposers submit Appendix A, B & E through the Navy SBIR/STTR Website and mail only the appendices to the Navy SBIR Program Office listed above.
5. The requirements and time frames for Navy Fast Track submission have been modified and are described below.
6. The Navy only accepts proposals with a base effort less than $70,000 with an option less than $30,000.

NEW THIS YEAR:

The Navy will allow firms to include with their proposals, success stories that have been submitted through the Navy SBIR/STTR Website at (**http://www.onr.navy.mil/sbir**). A "Navy Success Story" is any follow-on funds that a firm has received from past Phase II Navy SBIR or STTR awards. To qualify the firm must submit these success stories no later than **13 December 1998,** through the Navy SBIR Website. The success story should then be printed and included as appendices to the proposal. These pages will not be counted towards the 25-page limit.

The success story information will be used in the evaluation of the third criteria "Commercial Potential", (listed in Section 4.2 of this solicitation) which includes Companies Commercialization Report (Appendix E) and the strategy described to commercialize the technology discussed in the proposal. Commercialization is viewed as any follow-on funds, from the DOD, DOD contractors or the private sector, used to further develop the technology or from sales of a product. The Navy is very interested in companies that transition SBIR efforts directly into Navy and DOD programs and/or weapon systems. The proposing company should make reference to the attached success stories in the "Commercialization Strategy" section of their proposal so the evaluator knows to look for them. If a firm has never received any Navy SBIR Phase II it will not count against them, and they will be evaluated on the other evaluation criteria listed in Section 4.2 Phase I Evaluation Criteria. If you have any questions about this requirement, call John Williams at (703) 696-0342.

PROPOSAL SUBMISSION CHECKLIST:

SUBMIT YOUR PROPOSAL(S) WELL BEFORE THE DEADLINE.

All of the following criteria must be met or your proposal will be REJECTED.

1. You must use the electronic format described in the section Electronic Submission described below. The Navy will not accept any proposals that do not have electronic forms of Appendix A, B, and E. The electronic appendices submitted must match the paper copies submitted via mail/express delivery.

2. An electronic version of Appendix E must be submitted with all proposals. Even if you have no Phase II or Phase III information to report.

3. Your Phase I proposed cost for the base effort can not exceed $70,000. Your Phase I Option proposed cost can not exceed $30,000. The costs for the base and option should be clearly separate and identified on Appendix A, the cost proposal and in the work plan section of the proposal.

4. Your proposal must be received on or before the deadline date. The Navy will not accept late proposals, or incomplete proposals. If you have any questions or problems with submission of your proposal allow yourself time to contact the Navy and get an answer to your question. Submit Appendices early, as computer traffic increases, computer speed slows down. Do not wait until the last minute.

ELECTRONIC SUBMISSION OF APPENDICES:

Submit your SBIR proposal to the Navy using the online submission. This site allows your company to come in any time (prior to the closing of the solicitation) to edit or print out your appendicies. **The Navy WILL NOT accept any form from this book or any electronic download version except those from the Navy SBIR Website as valid proposal submission forms for the Appendix A, B and E.** Proposers must use the following procedures.

A. Go to http://www.onr.navy.mil/sbiros and click on "SBIR Phase I" box, or you can come through the Navy SBIR/STTR Website at http://www.navysbir.brtrc.com, click on "Submission", then click on "Submit or Edit Phase I Appendix A and B" and follow instructions.

B. Fill out all the information requested. The screen format will look different then the forms in the solicitation. Once you have filled in the data, follow the instructions to electronically save/submit appendices. That is, make sure you click on the Save/Submit button, which will save your appendix to the Navy server. You will still be able to return and edit this text up to solicitation closing, at which time the Navy will close down the site. Your electronically submitted version should match the signed paper appendicies submitted with your proposal.

C. After you click on the Save/Submit button, follow instructions to print out the appendicies and sign them. The printed forms from the website may look different than the forms in book and the signature block may appear on the second page. The Navy requires you to include these forms with the mailed hard copy of your proposal. Do not use any other version of the signed forms.

D. Mail the signed Appendix A/B and E forms along with one original and four copies of your entire proposal (the copies should include four copies of the signed Appendix A, B and E forms) to the Navy SBIR Program Office at the above address.

ELECTRONIC SUBMISSION OF PROJECT REPORTS:

The submission of an electronic Phase I Summary Report will now be required at the end of Phase I. The Phase I Summary Report is a summary of Phase I results, includes potential applications and benefits, and should not exceed 750 words. It should require minimal work from the contractor because most of this information is required in the final report. The summary of the final report will be submitted through the Navy SBIR/STTR Website at: http://www.onr.navy.mil/sbir, click on "Submission", then click on "Submit a Phase I or II Summary Report". If your company does not have access to the Internet on your computer consult your local library or local computer service store.

The Navy is initiating this new program to help increase the awareness and implementation of SBIR funded efforts. The goal is to increase the market potential and transition of SBIR projects by increasing the visibility and ease in accessing information about SBIR projects to DOD, government and DOD industry contacts. This should facilitate the transition of these projects into follow-on efforts and bring additional revenue to the SBIR Company.

To do this the Navy is asking companies to provide information on the status and benefits of their technology developments so that this information can be put into a media that others can easily access and review. The Navy plans to redistribute this information to a wide audience using such tools as the Navy Webpage, Accomplishment Book and a new interactive Navy SBIR

Website. This will help provide parties with technical challenges or those with the need to implement new technology, with a user-friendly mechanism to access and identify SBIR companies that can provide them with solutions. This information should be **non-proprietary** yet detailed enough to provide the interested transition partner with enough knowledge to understand the potential use and benefit to their program.

NAVY FAST TRACK DATES AND REQUIREMENTS:

All Fast Track Applications and required information must be sent to the Navy SBIR Program Manager at the address listed above and to the designated Contracting Officers Technical Monitor (the Technical Point of Contact (TPOC) for the contract and the appropriate Point of Contact at the end of this Introduction). The following dates and information are required by the company to qualify for the FAST TRACK program. All of the requirements listed in the Fast Track Section of the front of this solicitation must be met. The information provided below provides specific dates and some additional information that is required by the Navy SBIR Program Office.

Party/Days After Phase I Award	Required Deliverables
SBIR Company / 150 Days	- Fast Track Application and all supporting information. (See instructions in the DOD section of this Solicitation) - Phase II 5 Page Summary Proposal, as required of all Phase I Projects as described in Navy SBIR Website listed above. (It is strongly recommended that if you are contemplating the submittal of a Fast Track Application, you make your intention known to your technical point of contact (TPOC) and the SBIR SYSCOM Program Manager for that respective topic, as listed in this Navy section.)
SBIR Company /181 - 200 Days	- Phase II Proposal - Phase I Final Report
Navy / 201 - 215 Days	- Navy will formally Accept or Reject your Phase II proposal.
SBIR Company /45 Days after Acceptance	- Proof that Funding has been received by SBIR company.

ARE YOU A SUPPORT CONTRACTOR FOR A NAVY ACTIVITY?

Do you have employees occupying space in a Navy activity? Or do you have a support contract to provide services outside of an SBIR Phase I, II or III contract award? If so you must indicate this on the Appendix A form. The Navy is concerned with potential conflict of interest and if you reply yes to either of the above you may be precluded from participation in the Navy's SBIR Program in Phase I and Phase II.

YOUR SUBMISSION TO THE NAVY SBIR PROGRAM:

This solicitation contains a mix of topics. When preparing your proposal keep in mind that Phase I should address the feasibility of the solution to the topic. Be sure that you clearly identify the topic your proposal is addressing. The Phase I option should address the transition into the Phase II effort. The Phase II is the demonstration of the technology that was found feasible in Phase I. Only those Phase I awardees which have been invited to submit a Phase II proposal by the Navy technical point of contact (TPOC) during or at the end of a successful Phase I effort will be eligible to participate for a Phase II award (with the exception of Fast Track Phase II proposals). If you have been invited to submit a Phase II proposal to the Navy by the TPOC, obtain a copy of the Phase II instructions from the Navy SBIR Webpage or request the instructions from the a Navy SBIR Program officer. Phase III efforts should also be reported to the SBIR program office noted above.

The Navy will provide potential awardees the opportunity to reduce the gap between Phases I and Phase II if they provide a $70,000 maximum feasibility Phase I proposal and a fully costed, well defined ($30,000 maximum) Phase I Option to the Phase I. **The Navy will not accept Phase I proposals in excess of $70,000 (exclusive of the Phase I option).** The technical period of performance for the Phase I should be 6 months and for the Phase I option should be 3 months. The Phase I Option should be the initiation of the next phase of the SBIR project (i.e. initial part of Phase II). The Navy will also offer a "fast track" into Phase II to those companies that successfully obtain third party cash partnership funds ("fast track" is described in Section 4.5 of this solicitation). When you submit a Phase II proposal it should consist of three elements: 1) a $600,000 maximum demonstration phase of the SBIR project (i.e. Phase II)(Phase II efforts are for two (2) years no more, no less....Phase II options are for an additional six (6) months...a waiver may be granted only from the NAVY SBIR Program Office); 2) a transition or marketing plan (formally called a "commercialization plan") describing how, to whom and at what stage you will market your technology to the government and private sector; 3) a Phase II Option ($150,000 maximum) which would be a fully costed and well defined section describing a test

and evaluation plan or further R&D if the transition plan is evaluated as being successful. You must also submit your Phase II appendix A, B & E electronically to the Navy SBIR Program Office at the address above. While Phase I proposals with the option will adhere to the 25 page limit (section 3.3), Phase II proposals together with the Phase II Option will be limited to 40 pages (unless otherwise directed by the TPOC or contract). The transition plan should be in a separate document.

The Navy will evaluate and select Phase I proposals using scientific review criteria based upon technical merit and other criteria as discussed in this solicitation document. Due to limited funding, the Navy reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

Table 1. NAVY MISSION CRITICAL SCIENCE AND TECHNOLOGY AREAS

TECHNOLOGY AREAS	SCIENCE AREAS
Aerospace Propulsion and Power	Atmospheric and Space Science
Aerospace Vehicles	Biology and Medicine
Battlespace Environment	Chemistry
Chemical and Biological Defense	Cognitive and Neural
Clothing, Textiles and Food	Computer Sciences
Command, Control and Communications	Electronics
Computers, Software	Environmental Science
Conventional Weapons	Manufacturing Science
Electron Devices	Materials
Electronic Warfare	Mathematics
Environmental Quality and Civil Engineering	Mechanics
Human-System Interfaces	Ocean Science
Manpower, Personnel and Training Systems	Physics
Manufacturing Technology	Terrestrial Sciences
Materials, Processes and Structures	
Medical	
Sensors	
Surface/Undersurface Vehicles/Ground Vehicles	
Modeling and Simulation	

NAVY SBIR PROGRAM MANGERS OR POINTS OF CONTACT FOR TOPICS

TOPIC NUMBERS	POINT OF CONTACT/ACTIVITY	PHONE
N99-001 to N99-034	Mr. Douglas Harry (ONR)	703-696-4286
N99-035 to N99-043	Mr. Joe Johnson (MARCOR)	703-784-4801
N99-044 to N99-073	Ms. Carol VanWyk (NAVAIR)	301-342-0215
N99-074 to N99-158	Mr. William Degentesh (NAVSEA)	703-602-3005
N99-159 to N99-160	Mr. Mike Letsky (BUPERS)	703-614-6859
N99-161	Mr. Charles Marino (SSPO) Mr. Ron Vermillion (NSWC/DD/DAHL)	703-607-3444 540-653-8906
N99-162 to N99-163	Mr. Dennis Gaddis (NAVSUP)	717-790-7435
N99-164 to N99-173	Ms. Linda Whittington (SPAWAR)	619-537-0146

NAVY 99.1 TOPICS

OFFICE of NAVAL RESEARCH

N99-001 TITLE: Smart Active Networks

SCIENCE/TECHNOLOGY AREA: Command, Control and Communications

OBJECTIVE: Develop and insert new low-cost approaches to data collection and information management in a network-centric environment.

DESCRIPTION: Active networks enable routing elements to be programmed by packets passing through them; thus, allowing computation, previously possible only at endpoints, to be carried out within the network itself. This enables optimizations and extensions of current protocols as well as the development of fundamentally new protocols. The network itself may serve, moreover, as a smart virtual computational device.

PHASE I: Develop novel approaches for active networks, able to route active packets over low-bandwidth or wireless networks consistently and robustly. Develop low-cost network devices that support active network protocols. Design appropriate tools to support remote administration of network and network devices. Define an application of Naval interest, illustrating information processing capability of the network itself, and including realistic performance estimates.

PHASE II: Develop and validate technologies able to define, initialize, select, analyze, and maintain each supported active device and router, and able to do network registration, identification, authentication, audit, application-specific multicast, information fusion, system interconnection, mobility, recovery, and traffic load balancing. Build a realistic prototype based on the above cited application and analyze its performance, scaleability, and costs.

PHASE III: Prepare products for use by network administrators and instructors for civilian and military use. These products should be robust, extensible, compatible with major commercial standards, and suitable for use in advanced concept demonstrations.

COMMERCIAL POTENTIAL: Network information technology and network administration will benefit from affordable technology, capable of supporting local low-bandwidth network devices, and usable in applications from logistics to networked consumer appliances.

REFERENCES:

1. Cebrowski, Arthur K. and John J. Garstka, "Network-Centric Warfare: Its Origin and Future", Proceedings of the Naval Institute, (Jan 1998). URL: http://www.usni.org/Proceedings/Articles98/PROcebrowski.htm

2. Weiser, Mark, "The Computer for the 21st Century." Scientific American (Sep 1991). Related URL: http://www.ubiq.com/hypertext/weiser/SciAmDraft3.html

3. Tennenhouse, David, et al., "A Survey of Active Network Research" IEEE Communications Magazine, (Jan 1997). URL: http://www.tns.lcs.mit.edu/publications/ieeecomms97.html

KEY WORDS: network-centric; active networks; bandwidth; protocols, push-technology; ubiquitous computing

N99-002 TITLE: Quantum Devices and Circuits: Modeling and Design

SCIENCE/TECHNOLOGY AREA: Electronic Devices

OBJECTIVE: To explore the properties of quantum effect devices and develop new device concepts for use in extremely high speed digital applications and high sensitivity detectors of infrared radiation. To provide physics based models for quantum devices which can be validated by experiment. To develop new algorithms for quantum transport describing time dependent transport which will be incorporated in the device models.

DESCRIPTION: Computer programs for circuit simulation based on quantum effect devices must be developed, in which device parameters can be extracted from the physics models. Small signal and large signal applications must be described and simulated so that software packages enabling engineering design of advanced devices and circuits can be realized. Quantum tunneling devices, such as Resonant Tunneling Diodes (RTDs), have recently developed to the point that they are being considered for high speed digital circuits operating at 100 GHz, far beyond the upper frequency limits of silicon CMOS technology (i.e. 1 GHz). There is a great need for such circuits in Navy applications such as digital radar, digital receivers, and the Navy AMRFS project. High sensitivity IR Focal

Plane Arrays with multispectral capability have been proposed for ultra performance sensors and missile tracking. These applications need the advantages of very low operating power and circuit compactness intrinsic to quantum devices. The design and development of quantum devices and circuits requires realistic computer simulation tools based on quantum physics models; this requires further advances in quantum transport theory which can be applied in physics based models of tunneling devices. Time dependent effects must be included in quantum tunneling in order to meet the requirements of many of the applications. Real device models must be considered, including the material properties, the geometry, the contacts, etc. This approach will lead to greatly reduced development time and cost, since the output can be used as design tools, avoiding the empirical approaches currently used. A versatile simulation tool can be expected to lead to innovative new devices and applications not currently considered. The physics modeling of the devices will provide real parameters for inclusion in circuit simulations. These simulation will provide accurate, fast, and easy-to-use programs which can be implemented by design engineers. These programs are essential for evaluating many requirements of the applications, such as overall circuit speed, power dissipation, and evaluation of novel circuit architectures. An important requirement is the development of a user friendly and flexible simulation program for use on various computer platforms.

PHASE I: Develop quantum device simulation methods and expand on the theory of quantum transport, including time dependent processes, for inclusion in the physics models. Select appropriate circuit models for simulation and evaluation for the extremely high speed digital applications and for the detection application.

PHASE II: Physics based tunneling models will be further developed to include: 2D and 3D geometries, bandstructure of the multiple layer heterostructures, the adaption to any material implementation and full device configurations, including any contacts. Device parameters will be extracted for insertion into the circuit simulation program. Digital and analog circuit layouts will be designed and simulated for optimum high speed performance. This effort will require development of time dependent solutions to device physics and circuit response, including small and large signal response. Software interface will allow for user control of materials parameters, quantum device geometries, and circuit layouts.

PHASE III: The software product will be sold and/or made available to DoD laboratory and to industrial laboratories developing high frequency circuits under Navy sponsorship. These laboratories include NRL, HRL Labs, and Raytheon T I Systems. For detectors, NRL and JPL. As appropriate, these laboratories will provide technical data to be used in evaluating the software product before delivery or sale. Other government users include NASA, Lincoln Labs, and the Army Research Lab.

COMMERCIAL POTENTIAL: This product will be used by commercial interests to develop digital technology for satellite communications, digital cellular telephones, and for analog technology in covert communications, space communications, and for collision avoidance radar. Infrared detectors will find applications in surveillance. Ultra-low dissipation power and small size is essential to all applications.

REFERENCES:

1. Sun, J.P.et.al., "Resonant Tunneling diodes: Models and Properties," Proceedings of the IEEE, April 1988, pp. 641-663.
2. Mazumdar, P., et. al., "Digital Circuit Applications of Resonant Tunneling Devices," Proceedings of the IEEE, April 1998, pp. 664-688.

KEY WORDS: Terahertz; circuits; quantum; devices; sensors; digital

N99-003 TITLE: Integration of High Density Magnetic Memory into Silicon Electronics

SCIENCE/TECHNOLOGY AREA: Electron Devices

OBJECTIVE: To develop the designs and fabrication technologies for integrating Magnetic Random Access Memory, an advanced nonvolatile memory development at the Naval Research Laboratory, into silicon electronics for wide areas of application. The silicon electronics package will provide necessary power and the read and write wiring to the magnetic element array and will be compatible with commercial VLSI chip manufacturing.

DESCRIPTION: The ONR 6.2 Electronics program has developed an advanced, high density memory technology which utilizes arrays of magnetic metal multilayer elements to store digital information. The storage mechanism is based on the Giant Magneto-Resistive effect (GMR) recently discovered. The NRL development has a unique design which leads to an exceptional performance level, which continues to improve as element dimensions shrink below 1000 nanometers. This will permit storage densities far beyond those projected for silicon memory (DRAM) produced commercially, as well as other GMR memory concepts. Memory chips with capacity in excess of 100 Gigabits are projected. These magnetic elements are non-volatile, that is they retain their memory state even when power is removed. Power is used only in the read and write operations, and thus, power requirements in computation and communication applications will be reduced. In order to implement these memory elements into a VLSI compatible technology, where silicon circuits provide read/write currents to the memory elements, the power supply, and amplifiers for transmitting signals

to Central Processing Units, circuits must be designed which can match these functions to the memory arrays. These designs must permit the fabrication of the memory chips as a "back end" process, where the magnetic arrays are integrated at the end of the semiconductor processing and packaging.

PHASE I: The contractor will provide an analysis of the crucial issues in the silicon circuit design, including the trade-offs between density and speed, and the manufacturing constraints imposed by lithographic technologies. This analysis will be used to prepare a preliminary architecture and circuit design.

PHASE II: The contractor shall develop a detailed working circuit layout and will design the mask sets and instruction codes for the fabrication of a working silicon chip. These chips will be fabricated and tested. Finally, the contractor will integrate the magnetic memory arrays onto the functional silicon devices and demonstrate small functioning 1 kilobit arrays which represent memory densities of 10 Megabit per sq. in.

PHASE III: Functional MRAM arrays, scaled to appropriate memory capacity, will be designed and fabricated for insertion into several DoD applications requiring robust, non-volatile, low power memory. These applications include: NAVAIR MAST program; tactical missiles, A9-X, AMRAM and JASSAM which require memory storage to enable programming; upgrades to mission computers in AV-8, F-14 and F-18. Other versions will be replacements for semiconductor memory in portable applications such as computers and cellular communication.

COMMERCIAL POTENTIAL: This novel memory technology will provide low-power, nonvolatile memory at the speed and density of current DRAM and SRAM at lower production cost. Being nonvolatile, it could be a replacement for all memory chips and because of high density potential, could replace mechanically driven hard disk drive storage units.

REFERENCES:
1. Daughton, J. M., "Magnetic Tunneling Applied to Memory",Journal of Applied Physics, 81, 3758 (1997)
2. Granley, G. B. and Hurst, A. T., Proceedings of the 6th IEEE International Nonvolatile Memory Technology Conference, 138 (Albuquerque, NM) (1996) Pub. 96 TH 8200

KEY WORDS: Memory; Nonvolatile; Giant-Magnetoresistance; Magnetism; Chip; Random Access Memory

N99-004 TITLE: Alternative Lossy Dielectrics for High Power Vacuum Electron Devices

SCIENCE/TECHNOLOGY AREA: Electron Devices

OBJECTIVE: To develop vacuum compatible, electrically lossy, high thermal conductivity alternatives to existing BeO-SiC composites currently used high power vacuum electron devices.

DESCRIPTION: As future DoD radar, communications, and ECM needs push for operation at higher average powers, bandwidths, and frequencies, high-performance vacuum electron devices are running into the limitations of currently available vacuum-compatible materials to accommodate high thermal loading, tailored electromagnetic losses, and high dielectric strength. In addition, there is a developing crisis in the domestic availability of certain (toxic) materials, such as BeO-SiC composites, critical to the manufacture of high power vacuum electron devices. This project seeks to develop alternatives BeO-SiC composite materials.

PHASE I: Identify promising candidate materials that can potentially meet the vacuum, thermal, and electromagnetic requirements currently served by BeO-SiC. In addition, identify promising materials processing techniques to create such high thermal conductivity materials with tailored electromagnetic properties consistent with operation in high power vacuum electron devices.

PHASE II: Fabricate candidate materials using the techniques and processes identified in PHASE I. Evaluate the thermal, mechanical, and electromagnetic properties of these materials, and demonstrate their effectiveness in realistic high power rf environments. Demonstrate that promising materials can be integrated into realistic vacuum electron device fabrication processes. Fabricate and demonstrate a working device, such as a high power klystron or traveling-wave tube, utilizing the new material(s).

PHASE III: The successful development of a new material or materials, and the appropriate materials processing techniques will be transitioned to the NRL Vacuum Electronics Branch and disseminated, through them, to the U.S. vacuum electron device industry.

COMMERCIAL POTENTIAL: Almost every medium-to-high vacuum electron device in the DoD inventory uses BeO, either in its pure form as a vacuum window or insulator, or as a composite (typically with SiC), functioning as a lossy dielectric used to suppress unwanted electromagnetic oscillations (TWT circuit severs, klystron-cavity loss buttons, support structures, etc.). In the past year, economic pressures and increasingly stringent federal and local regulations have reduced the number of U.S. suppliers of BeO-SiC to one, which has increased materials costs and threatens the U.S. supply base. The lack of an acceptable substitute for

BeO-SiC has a potentially negative impact on all medium-to-high power military and commercial systems using vacuum electron devices. The development of a replacement material for BeO-SiC has a significant impact on these important systems.

REFERENCES: "Industrial Assessment of the Microwave Power Tube Industry," DoD report, April 1997.

KEY WORDS: lossy dielectrics, BeO-SiC, TWT, klystron.

N99-005 TITLE: Single-Chip Silicon-on-Insulator Global Positioning System

SCIENCE/TECHNOLOGY AREA: Electronics

OBJECTIVE: To develop a low-power, low-cost Global Positioning System (GPS) by designing and fabricating a GPS integrated circuit (IC), including both radio frequency (RF) and digital functions, on a single chip of silicon-on-insulator (SOI) material.

DESCRIPTION: A single-chip GPS would combine high-frequency RF analog processing circuits with digital signal processing circuits for geolocation output. This cannot be achieved using conventional CMOS technology on silicon because the conductive silicon substrate does not allow adequate high-frequency isolation to integrate the RF and digital circuits. By exploiting the insulating substrate of thin film silicon-on-insulator materials for high-frequency RF isolation, integration of both RF analog circuits and digital processing circuits on a single-chip IC should be enabled. To maximize high-frequency RF isolation properties the preferred SOI substrate would be silicon-on-sapphire. To insure dual-use capabilities, it will be necessary to demonstrate design feasibility for single-chip GPS IC's capable of operating in both the military and civilian frequency bands.

PHASE I: Design and analysis of GPS architectures will be performed to demonstrate concept feasibility. This will include specification of optimized designs, manufacturing processes and materials.

PHASE II: Single-chip GPS fabrication, test and evaluation will be performed. Working prototype single-chip GPS IC's based on SOI materials will be fabricated and demonstrated for both military and civilian frequency bands. A transition plan for developing a commercial manufacturing capability will be developed.

PHASE III: A manufacturing capability will be established to fabricate single-chip GPS products for military and civilian markets.

COMMERCIAL POTENTIAL: GPS products are already in widespread use for military and civilian applications. The primary improvement expected from the program will be to produce extremely low-power GPS products which can operate for extended periods on battery power. The secondary expected improvement is that a single-chip IC system combining RF and digital circuitry should be low-cost in comparison to present technology, even after allowing for the expense of using SOI technology. GPS products with these improvements would rapidly dominate future military and civilian markets worth billions of dollars.

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2. R. A. Johnson, "Silicon-on-Sapphire Technology for Microwave Circuit Applications," dissertation submitted in partial fulfillment of requirements for the degree of Doctor of Philosophy in Electrical Engineering, University of California, San Diego, May 1997.

KEY WORDS: Silicon-on-Insulator; Silicon-on-Sapphire, Global Positioning System; RF integrated circuits; analog and digital functions on a single chip; wireless communications.

N99-006 TITLE: Improved Efficiency of Multicolor Light Emitting Devices Based on Short-Wavelength LEDs with Down-Converting Phosphors or Polymers

SCIENCE/TECHNOLOGY AREA: Electron Devices

OBJECTIVE: Develop novel approaches to improve the efficiency of multi-color LEDs for lighting or display applications.

DESCRIPTION: The ability to produce visible radiation in a controlled manner is the basis for almost all indoor and outdoor lighting as well as the production of all monochrome and color displays. A wide variety of technologies are used to produce visible light, including those based on incandescence (light bulbs), fluorescence (fluorescent lights) and electroluminescence (light emitting diodes or LEDs). The selection of these various technologies depend on the color, intensity, geometry and costs associated with the

particular application. Of particular importance is the ability to produce visible radiation at low cost. Until recently, LEDs have been used primarily for low intensity monochromatic lighting applications such as indicator lights or alphanumeric displays. While LEDs are available over the entire color spectrum, the semiconductor material from which it is made fixes the specific color of an LED. The first LEDs emitted in the infrared and red, and as materials research advanced, other colors became available, with blue LEDs being a relatively recent addition to the range of colors available from LEDs.

Advances in materials research and device fabrication have increased the intensity of red, green and blue LEDs dramatically, so that the light intensity emitted at a particular wavelength can rival that of light bulbs with color filters. This is evident from the use of high brightness red LEDs in automotive tail light applications. The recently developed (InAlGa)N LEDs emitting in the blue and green are of much higher efficiency than even the high brightness red LEDs based on the (AlGa)As materials system [1]. By combining LEDs of the three primary colors, bright, full color displays can be fabricated. However, such displays require assembling large collections of discrete LEDs, since the different colors required are made from different semiconductor compounds.

Another approach to the use of LEDs for the production of visible radiation is to use blue or ultraviolet(UV) emission from (InAlGa)N blue LEDs to excite phosphors [2]. Upon absorption of UV light, the phosphor converts the energy to visible radiation of a color, including white light, depending on the type of phosphor used. Polymeric resins and dye-impregnated plastics can also be used wavelength down-conversion. A wide range of high efficiency phosphors are commercially available, having been used for fluorescent lighting and television screens for many decades. The coupling of a high brightness LEDs and a phosphor has been used to create new, efficient and compact lighting and this technology could be extended to color display systems.

Prototype 'white-light' LEDs are currently available however these devices have a lower efficiency (5.0-7.5 Watts/Lumen) than incandescent lighting (15 Watts/Lumen) and much lower than the theoretical maximum (150 Watts/Lumen)at this time. Improvements need to be made to the external quantum efficiency (QE)of the LED and to the coupling to the phosphor to minimize the strong waveguiding due to the high refractive index of the active region of the LED. The strong waveguiding may limit pixel size in displays if the LED emission cannot be efficiently coupled. In addition, the current approach available in the market only appears 'white' to the eye (it is a mixture of blue (LED) and yellow (phosphor) emission) so the color-rendering index (CRI) needs to be improved. Issues associated with the long-term stability of the phosphor and binders to the exposure of UV radiation over an extended period of time also need to be addressed.

PHASE I: In PHASE 1 schemes to improve the QE of the UV/blue pump source, the coupling efficiency of the phosphor or polymer and the CRI should be explored and demonstrated.

PHASE II: Further development, optimization and packaging of devices will be completed. Scaling and manufacturing issues such as emission over large areas, addressable arrays, etc..

PHASE III: DUAL USE APPLICATIONS: Current military display systems are usually monochrome but require large area multicolor capability for realtime battlefield applications. Single-element indicator lights and monochrome- and multi-color displays represent a market much larger than that of diode lasers in particular if applied to domestic lighting.

COMMERCIAL POTENTIAL: Lighting , and automotive, laptop display industry

REFERENCES:

1. Nakamura et al., Appl. Phys. Lett. 67 (1995), 1868.
2. Sato, N. Takahashi, and S. Sato, Jpn. J. Appl. Phys 35 (1996), L838.

KEY WORDS: LEDs, Display. Polymers, Phosphors

N99-007 TITLE: Improved Performance 10 Kelvin Refrigerator for Electronic Applications

SCIENCE/TECHNOLOGY AREA: Electronics

OBJECTIVE: Design, fabricate and validate the concept of an affordable, compact, lightweight, energy-efficient closed cycle refrigerator capable of providing 100 to 200 milliwatts of cooling capacity at 10 Kelvin for use with terrestrially-deployed superconducting digital circuits and subsystems, Josephson voltage standards, and long wavelength infrared imaging cameras. Units suitable for a spatially distributed array of circuits are also desired.

DESCRIPTION: Cryogenic cooling enables long wave length infrared detectors and complex superconducting circuits. Todays choices include satellite units having the desired performance but costing ~ $1M and overly large units designed for cooling superconducting MRI magnets or absorption pumps that are too heavy and too energy-inefficient to be deployed with electronic devices and circuits. This program seeks to produce an affordable unit optimized for cooling small electronic systems to temperatures near 10 K in a configuration which is small, lightweight and very energy efficient. The performance goals are as follows: Cooling

Capacity: 200 (100) milliwatts goal (acceptable) ; Operating Temperature: 9 K.(10K) - goal (acceptable); Electrical Input Power: 150 (300) watts - goal (acceptable) ; Weight: 10 (30) kilograms - goal (acceptable). Other goals are Cost (in quantity production) ~ $ 10,000; Operating Lifetime: greater than 40,000 hours; turn-key operation; minimal EMI and vibration. Both integral and split configuration, single and double stage designs are acceptable. Choice of the compressor and low temperature regenerators will be important to achieving the cost and reliability goals. The focus of this SBIR is for terrestrial applications: those organizations interested in the development of similar equipment for space deployment are referred to Air Force SBIR AF-99-061

PHASE I: Determine which thermodynamic cooling technologies (Stirling with flexure bearings, free piston Starling, pulse tube, absorption, Brayton, etc.) are capable of achieving the desired thermal, electrical and mechanical specification. Select one or two as the most promising. Define and model performance determinants of a candidate system which could satisfy the goal specifications.

PHASE II: Design, fabricate and evaluate the performance of the selected refrigeration system. Verify that the performance approximates the goals and exceeds the specified acceptable levels of thermal, electrical, and mechanical characteristics of the system. If not, define what modifications must be made to approach the goal values.

PHASE III: Optimize the refrigerator design for integration into a cryogenic system with a niobium nitride Josephson voltage standard, a niobium nitride very high frequency analog to digital converter in a radar or multi-function rf system, or with a cooled VLWIR imaging detector array. This should be done in close collaboration with a commercial vendor of these chips.

COMMERCIAL POTENTIAL: These refrigerators will expedite the use of high speed superconducting digital logic including analog-to-digital converters and digital SQUIDs in laboratory instrumentation, the wide-spread use of very precise Josephson voltage standards for metrological applications, and can improve the resolution and energy sensitivity of infra-red (IR) imaging sensors. Their possible use as oil-free, cryogenic vacuum pumps for small volume systems should also be explored.

REFERENCES: AL.D. Crawford, et al, An Overview of the Air Force Philips Lab Cryocooler Program, p. 3-10 of Cryocoolers 9, ed. R.G. Ross, Jr., Plenum (NYC, 1998).

KEY WORDS: cryogenic refrigerators, cryocoolers, 10 Kelvin, digital superconductivity, VLWIR infrared sensor, analog-to-digital converters

N99-008 TITLE: Wide Bandgap Semiconductor IMPATT Diodes

SCIENCE/TECHNOLOGY AREA: Electron Devices

OBJECTIVE: This work seeks to exploit recent advances in wide bandgap semiconductor (WBS) materials to develop high power, high efficiency Impact Avalanche Transit Time (IMPATT) diode oscillators for operation at 35 GHz and above.

DESCRIPTION: As a result of their high breakdown field (~ 3 MV/cm) and high carrier saturation velocity (~2.5×10^7 cm/s), the WBS (namely SiC and GaN) are ideal candidate materials for the realization of high power, high efficiency IMPATT diodes. SiC has the added advantage of a high thermal conductivity (4.9 W/cm K) while GaN has the benefit of heterostructures with AlGaN to tailor the band structure. These properties imply that SiC or GaN based IMPATTs should deliver 100 times the output power of GaAs-based devices since $P_{out}\%v_s^2E_c^2$.

While SiC IMPATTs were studied previously, high frequency oscillators were not demonstrated due to insufficient material and process capabilities at the time (1). With recent advances in the epitaxy and process technology of both SiC and GaN it should now be feasible to produce high power (20 W at 35 GHz) two-terminal oscillators in SiC or GaN (2-4).

PHASE I: The contractor shall develop the process technology, device design, and device model for a high power, high efficiency IMPATT diodes operating at 35 GHz based on SiC or GaN. At a minimum, a reliable, low specific contact resistance ($<5 \times 10^{-6}\ \Omega\text{-cm}^2$) p-type contact shall be demonstrated to p^+-material. Alternatively, a low leakage Schottky contact approach may be proposed. In addition, p^+/n diodes with low reverse leakage and abrupt reverse avalanche breakdown at > 10^6V/cm shall be demonstrated. Detailed device simulations shall be performed to determine the optimum device structure.

PHASE II: The contractor shall continue to optimize power and efficiency in order to demonstrate a packaged SiC or GaN-based IMPATT operating at 35 GHz with 20 W of CW or long pulse (> 20-30% duty cycle, >30 microsec pulse) output power. The DC to rf conversion efficiency shall be greater than 15%. It is desirable that the proposed effort be coupled to Naval Air Warfare Center (NAWC) Weapons Division work on IMPATT diodes (presently GaAs and InP-based) for missile seekers (http://www.mugu.navy.mil).

PHASE III: The contractor should be able to supply high power, high efficiency IMPATT diodes for developmental missile seekers operating at 35 GHz and above. Power levels of >50 W and DC to rf conversion efficiencies of >20% shall be obtained. Teaming with NAWC in PHASE III would be desirable.

COMMERCIAL POTENTIAL: This work is expected to engender more powerful microwave and mm-wave sources for advanced radar and collision avoidance systems.

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4. S. N. Mohammad, A. A. Salvador, and H. Morkoc, AEmerging gallium nitride based devices, Proc. IEEE, 83, 1306 (1995).

KEY WORDS: microwave: IMPATT, wide bandgap, silicon carbide, gallium nitride

N99-009 TITLE: High Data Rate Code Division Multiple Access Satellite Network Modem

SCIENCE/TECHNOLOGY AREA: Command, Control and Communications

OBJECTIVE: Develop a code division multiple access (CDMA) modulator and demodulator that will support high data rate (HDR) (T1 >) and medium data rate (MDR) (128Kbps -T1) multimedia network data traffic simultaneously from multiple very small aperture terminal (VSAT) commercial satellite users. This program will leverage technology from existing ONR R&D programs, developing hardware to support the implementation of HDR VSAT SATCOM networks to support naval and Marine forces.

DESCRIPTION: Existing HDR satellite communications (SATCOM) work has demonstrated the ability to achieve T1 class speeds over commercial Ku band satellites using 60cm VSATs and direct sequence spread spectrum (DSSS) technology [1,2]. CDMA SATCOM modem technology is desired to support multiple access and improve system efficiency. HDR CDMA SATCOM modem technology will need the ability to: 1) incorporate adaptive bandwidth efficient modulation types, 2) dynamically implement power control schemes, 3) support adaptive forward error correction (FEC), 4) dynamically adjust data rate and code rate to achieve variable processing gains, 5) be flexible in CDMA code selection, 6) operate over commercial satellite transponders, and 7) operate at commercially accepted intermediate frequencies (e.g., 70MHz and 140MHz). Current DSSS modems lack much of the flexibility necessary to efficiently implement a satellite based VSAT network and current CDMA SATCOM modems operate at unacceptably low data rates to support many multimedia networked applications.

NRL has a CDMA VSAT SATCOM network testbed that can be made available to the contractor, on a not-to-interfere basis, should it be needed to support this development.

PHASE I: Develop or modify a CDMA modulator / demodulator pair with the capabilities listed above. The developer will have the responsibility for identifying appropriate hardware interfaces to support connectivity to baseband devices (i.e. network switches, routers, ...) and radio frequency hardware (i.e. up/down converters). The prototype should be flexible enough to support commercially accepted interfaces and interfaces currently in use by the Navy.

PHASE II: Integrate modulators and demodulators into a VSAT SATCOM network supporting multiple nodes in a full mesh and/or star topology. The nodes shall each support flexibility, as previously defined, to address various RF paths and impediments to the RF path by dynamically adjusting power, FEC, data rate, and code rate in an attempt to maintain connectivity at acceptable BER for given network offered load.

PHASE III: Provide a turnkey HDR CDMA VSAT modulator/demodulator system for field testing on Navy platforms.

COMMERCIAL POTENTIAL: The commercial market for VSAT SATCOM networks is large and growing. Many of CDMA's desirable features from the military perspective (reduced antenna aperture, increased satellite transponder efficiency, reduced requirement for network level timing, ability to capture collided signals) have direct applicability in commercial VSAT networks.

REFERENCES:

[1] http://w3.nrl.navy.mil/projects/HDRSATCOM

[2] Rupar, Michael (et. al.), "Demonstration of High Data Rate and Medium Data Rate VSAT Communications using the Global Broadcast Transponder.", NRL/MR/5550—97-7921, March, '97.

KEY WORDS: SATCOM, NETWORKING, CDMA, VSAT,

N99-010 TITLE: Four dimensional (4-D) Atmospheric and Oceanographic Instrumentation

SCIENCE/TECHNOLOGY AREA: Ocean Science

OBJECTIVE: Develop low-weight, low-power, and low-volume instruments/sensors/techniques to autonomously measure atmospheric and/or oceanographic parameters.

DESCRIPTION: Innovative sensors and measurement techniques are solicited to obtain meteorological and oceanographic (METOC) variables (e.g., physical, chemical, optical, acoustic, geophysical or biological) in 3-D space and time. The emphasis should be placed on (1) novel approaches and concepts for measuring a particular parameter coherently in 4-D, (2) observations which can be conducted as autonomously as possible (i.e. for independent operation on Remotely Piloted Aircraft (RPA), Autonomous Underwater Vehicles (AUV's), buoys or with expendable instruments), (3) providing a significant reduction in instrument weight and volume without reducing fidelity or resolution as compared to current state-of-the-art devices, and (4) developing the next generation of low cost, potentially expendable instrumentation usable in both navy operational scenarios as well as in S & T environmental data collection. Examples of some of the types of instruments solicited include: bathythermographs, *in situ* ocean wave directional spectral instruments, and the next generation of low cost METOC expendable instrumentation. The term Expendable Instrumentation includes both one time usage as well as long time *in situ* usage, and the sensors should be affordable if expendability is required but reusable if not. Included are instrumentation development efforts that would result in significant improvements and costs savings for existing expendable instrumentation, or would develop new expendable capabilities for measurements currently obtainable by other means (such as aerosol properties, visibility, IR extinction, etc.). All platform deployment scenarios (shipboard, submarine, and aircraft) are included. Priority is given to devices that can lead to substantial improvements in anti-submarine warfare (ASW), mine warfare (MIW), ship self-defense, airstrike targeting and special operations, through improved battle space environmental knowledge.

PHASE I: Provide both an exact description of the parameter to be measured including accuracy and sensitivity along with the instrument design concept for achieving the measurement.

PHASE II: Produce a viable prototype system and demonstrate its ability to support field measurements from an operating autonomous research platform.

PHASE III: Transition the technology to scientific use in the atmospheric, oceanographic or environmental monitoring research communities, and operational DOD systems.

COMMERCIAL POTENTIAL: New instruments can be used in a wide variety of commercial environmental monitoring systems.

KEYWORDS: meteorology; oceanography; instruments; miniaturize; automation; expendable

N99-011 TITLE: Directional Underwater Acoustic Communications Transducer

SCIENCE/TECHNOLOGY AREA: Command, Control and Communications

OBJECTIVE: Develop a directional underwater transducer for transmitting and/or receiving wideband acoustic communication signals at modem terminals located on, or moored to, the seafloor. The transducer beam should be steerable in all azimuths, either electrically or mechanically, possibly by means of embedded microprocessors. The transducer can be in the form of a refractive lens, reflective dish, antenna, array, parametric sonar, DIFAR, or any other configuration that is affordable, packagable, deployable, and reliable.

DESCRIPTION: The U.S. Navy is advancing deployable, autonomous, distributed systems for surveillance and other undersea applications. The nodes of these systems include low-cost acoustic modems providing wireless links to adjacent nodes. Present transducers are simple vertical line arrays exhibiting omnidirectional response in azimuth and reduced response at high elevation angles. Azimuthal transmit directionality would enhance overall network performance by reducing total transmit power, reducing interceptability, and improving multiple-access network performance. Azimuthal receive directionality would increase signal-to-noise ratios.

PHASE I: Develop a prototype directional, steerable transducer compatible with an arbitrary 5-kHz band located in the 8- to 20-kHz acoustic spectrum. Examine the issue of tilt and motion sensitivity. Participate in a Navy-conducted sea experiment where the transducer will be evaluated using the U.S. Navy telesonar testbed.

PHASE II: Refine the transducer design for reduced cost, improved performance, high reliability, and ease of manufacture. Implement an appropriate strategy for tilt and motion immunity or compensation. Incorporate a means for true bearing determination. Use TRANSDEC or equivalent facilities for engineering development and calibration. Use Navy-provided opportunities for critical engineering sea tests. Show that the transducer can be mass-produced at a unit cost below $1,000. Integrate the transducer with a

commercial acoustic modem and demonstrate performance.

PHASE III: Produce a commercial acoustic modem product based on the transducer technology.

COMMERCIAL POTENTIAL: This technology will improve undersea acoustic communications and other acoustic signaling. Commercial markets include oceanography, recreation, oil exploration, undersea mining, navigation, and climatology.

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1. K.E. Scussel, J.A. Rice and S. Merriam, "A new MFSK modem for communication in adverse underwater channels," *Proc. IEEE Oceans'97*, Halifax, Nova Scotia, Canada, October 1997.
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KEY WORDS: undersea acoustics; acoustic communication; undersea networks; telesonar; acoustic lenses; sonar; acoustic arrays; transducers; electroacoustics

N99-012 TITLE: Engineering Modeling of Cable Spans and Bend Radii for Cables and Pipes Laying on Irregular Bottoms

SCIENCE/TECHNOLOGY AREA: Communications, command and Control

OBJECTIVE: To develop an analytical/numerical tool that will allow the user to have a true and accurate representation of a cable's shape as it lays on an irregular bottom terrain, including the unsupported spans and points of contact at the bottom, as well as the bend radii developed at the contact points (to compute induced stresses).

DESCRIPTION: Both the Navy and the commercial industry have a need to develop a stand alone, user-friendly, Windows NT based computer program that will allow the user to calculate quickly the locations and lengths of free spans as well as the bend radii for cables and pipes laid on an irregular bottom terrain. As the cable is laid over the ocean bottom, it will bend over obstacles, and its free spans will become a strong function of the bottom roughness. Given the values of water depth along specific bottom tracks, cable properties (wet weight and bending stiffness), and cable bottom tension, the program would determine the lengths and locations of the spans and the bend radii.

PHASE I: Develop the algorithms necessary to numerically determine locations and lengths of free spans as well as the bend radii for cables and pipes laid on irregular bottom terrain. Newly developed algorithms must be fast enough to compute solutions in almost real-time on a standard PC-based computer. Application of this technology to reduce time during at sea survey operations is one of the goals of this project.

PHASE II: PHASE I algorithms will be incorporated into a PC-based computer program modified to incorporate the effects of various types of in-line cables and in-line bodies typical of ASW cable systems. Results predicted by the program will be rigorously validated with experiment data.

PHASE III: Develop naval applications of the program, such as anti-submarine warfare operations.

COMMERCIAL POTENTIAL: The commercial sector will benefit from this because it will reduce the time taken in the selection of appropriate cable and pipeline routes. As the survey is progressing, the user could simulate the lay of his specific cable along different tracks and determine if this tool can be useful in establishing the tension the cable should be laid along different portions of the lay in order to minimize suspensions.

KEYWORDS: cable bends, cable shape, cable spans, cable stresses and radii computation

N99-013 TITLE: Non-Explosive, Electrically Initiated Linear Shape Charge Technologies for Salvage and Obstacle Clearance Operations

SCIENCE/TECHNOLOGY AREA: Conventional Weapons

OBJECTIVE: Develop and demonstrate solid fuel/water compositions and methodology for electrically initiated non-explosive linear shaped charges.

DESCRIPTION: The US Navy has the mission to conduct develop and deploy technologies for a rapidly deployable, chokepoint salvage clearance system, and to develop the ability to conduct rapid destruction of obstacles in surf and beach areas. Recent studies have shown that it may be possible to develop non-explosive, electrically initiated reactive systems which are capable of generating

energy release levels and rates characteristic of explosive systems. This effort would develop this technology, and design and demonstrate a non-explosive, electrically initiated prototype linear shaped charge device which has the potential to address these mission needs.

PHASE I: Identify candidate reactants and configurations. Conduct thermochemical analyses and trade-off studies of candidate fuel/oxidizer systems, electrical energy and power requirements. Fabricate test samples and perform essential tests for measurement of the pressure of reactants activated immediately by energetic electrical pulses.

PHASE II: Optimize candidate fuel/oxidizer formulation and solid configurations. Test activation and initiation thresholds and outputs. Optimize peak pressures and pressure-time histories for shape charge applications. Conduct tests to determine and optimize metal-driving capabilities. Obtain the equations of state. Design shaped charges liners to optimize performance for an electrically-activated system. Test charge/line configurations to verify that the performance meets prespecified requirements. Build and test a power unit prototype capable of adequately activating the reactive system. Verify its ability to function continuously in appropriate environments. Develop and demonstrate a cost-effective prototype system. PHASE III: Transition technology into 6.2/6.3 Logistics and Mine Warfare programs for logistics and obstacle clearance applications, NAVSEA 00C Salvage and Diving program; and salvage and demolition programs for industrial and civil engineering applications.

COMMERCIAL POTENTIAL The technology developed under this effort can be used exploited by the commercial demolition, salvage, and mining industries. Currently large amounts of explosive bulk and shaped charges are used to demolish large structures such as high rise buildings and sea-borne oil platforms, and very tedious and difficult torching operations are used in ship salvage operations. This technology promises to replace these very dangerous operations with safer, more efficient, non-explosive ones. It will also substantially reduce the hazards currently associated with the storage and transportation (both by land and sea)of thousands of pounds of explosive devices currently required for these operations.

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KEY WORDS: electrically activated reactions; pulse formed networks; linear shaped charges; salvage; obstacle clearance; logistics

N99-014 TITLE: Development of Advanced Electrode Materials for Rechargeable Lithium Batteries

SCIENCE/TECHNOLOGY AREA: Materials

OBJECTIVE: Synthesize, characterize and demonstrate novel cathode materials of high energy density for electrochemical power sources for undersea vehicle propulsion which will provide significant performance improvement over the present state-of-the-art silver/zinc (Ag/Zn) batteries.

DESCRIPTION: Rechargeable Ag/Zn batteries are currently used in a wide variety of Navy applications including undersea vehicle propulsion in the Deep Submergence Rescue Vehicle (DSRV), the MK30 Torpedo Target, the SEAL Delivery Vehicle (SDV) and the Advanced Swimmer Delivery System (ASDS). These cells have excellent power capabilities, but mission duration is limited by their energy. Nevertheless, Ag/Zn batteries at present have the highest energy density of any commercially available battery. While other electrochemistries have been under development by the Navy to increase energy density (1,2), cathode materials that have theoretical energy densities of 1500-1750 Wh/Kg are now sought to be used in cells of even higher energy densities. Against a lithium metal anode, cathodes with 300 Ah/kg at 5 V or 550 Ah/kg at 3 V, with little, if any, fading on cycling, would be candidates. Intercalating oxides remain strong candidates, and a recent review has shown how structural and chemical engineering of these can lead to improved performance (3). Candidates other than the oxides also have been identified, such as nickel Chevrel-PHASE sulfides (4). While this SBIR initially addresses high-energy dense cathodes, materials of high voltage (such as the 4.9 V $LiNiVO_4$ (5)) subsequently will need to be screened for the stability of proposed electrolytes against them (as was done, for $Li_{1+x}Mn_2O_4$ (6)).

PHASE I: Employ a theoretical basis supported by the technical literature to suggest improved cathode materials and then synthesize and electrochemically characterize candidate materials. Cycling ability must be demonstrated, but electrolyte optimization need not be accomplished in this PHASE. Select suitable techniques to characterize the materials and enable reproducible preparation. Demonstrate the material's performance using laboratory-type cells.

PHASE II: Perform screening tests to optimize the electrolyte composition and other cathode components such as binders

and/or conductive diluents. Build an adequate number of small (~1 Ah) cells to demonstrate the system's performance as functions of temperature, rate, and physical parameters of the cathode such as thickness and density.

PHASE III: Scale-up cell size to retrofit to a present Navy application, such as for propulsion of the SDV. Demonstrate as single cells and as batteries of 4-6 cells. Subsequently demonstrate as full-scale battery for a land-based test.

COMMERCIAL POTENTIAL: This battery could be applied to power commercial surface and undersea marine vehicles and would be a candidate for land-based electric vehicles.

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KEY WORDS: cathodes; batteries; electrochemistry; high-energy; undersea; power;

N99-015 TITLE: Carbon Nanotube Composites for EMI Shielding

SCIENCE/TECHNOLOGY AREA: Materials

OBJECTIVE: This program seeks to develop a carbon nanotube (single or multi-walled) composite that is strong, light wieght, electrically conducting, and able to shield electronic components in Navy aircraft and ships. It is envisioned that carbon nanotube composites will provide the basis for light wieght structural shielding of transmitted EMI.

DESCRIPTION: Navy platforms incorporate a variety electronic systems which emit and which can potentially be adversely affected by a variety of electromagnetic frequencies. Metals which are good conductors, such as copper, are often the basis of for shielding equipment from EMI. These materials also have the advantage of being structurally robust. The disadvantages are in wieght and the ability to readily mold and shape for required usage. Recent advances in carbon nanotube science and technology provide a unique opportunity to develop new classes of structural and electronic materials with properties ideal for EMI shielding applications. Multiwalled carbon nanotubes have been available for some time and more recently researchers are now able to provide workable quantities of single walled nanotubes. The SWNT have been predicted to have tensile strengths 40-100 times that of steel yet at 1/6 the weight. These SWNT nanotubes also have extraordinary electrical conductivities rivaling that of copper. Combining the properties of high conductivity with robust structure provide a opportunity for a new type of EMI shielding materials. Efforts will identify specific shielding requirements at a given frequency range where a nanotube based composites will have a significant improvement (wieght, thickness) over other shielding methods.

PHASE I: Identify and synthesize appropriate nanotube/polymer combinations to address shielding requirements over frequency range proposed. Activities should, through modeling and/or experiment, identify the potential for achieving high strength/light weight, highly conductive composites. Ideally the composite properties will be isotropic and will ultimately focus of use of the single walled nanotubes.

PHASE II: Activities will focus on polymer/nanotube interactions and optimization. This can include but is not limit to studies of phase segregation, rheology, and chemical interactions of polymer and nanotube. In addition it is envisioned that the PHASE II activities conclusively demonstrate test pieces with significant enhancement (wieght, thickness, frequencies) in EMI shielding capabilities.

PHASE III: Efforts will focus on cost analysis/reduction and testing of composites for Navy application. Testing included effectiveness against EMI as well as reduction of EMI signature combined with demonstration of robust mechanical properties. Large composite strength tests will be undertaken.

COMMERCIAL POTENTIAL: The commercial aerospace industry would benefit of conducting, lightweight, high strength composites for structures and electronic systems. It is also envisioned that these materials will be suitable for EMI shielding in consumer electronics. From a purely mechanical perspective, in the area of personal armor there would be significant commercial potential in alternatives to Kevlar.

KEY WORDS: carbon, nanotube, composite, conductors, high strength, polymers

REFERENCE: MIL-STD-461D provides a variety requirements for various EMI shielding considerations. This reference is meant only as a guide, not as a specification for this topic.

N99-016 TITLE: Rare Earth Doped Polymer Waveguide Amplifiers for High Data Rate Networks

SCIENCE/TECHNOLOGY AREA: Command, Control and Communications

OBJECTIVE: To meet the needs for future Naval systems, such as PHASEd array radar, that require ultra-high (> 10 Gbps) information data transfer rates, high performance optical fibers are required. Polymer Optical Fibers (POFs) are tough and have a high aperture, but decreased loss and improved signal amplification are required. To realize high performance, compact, rare earth doped POF amplifiers are needed. The objective of this effort is to develop dye doped POF's with high concentrations of erbium ions and long excited-state lifetimes so as to enable the fabrication of amplifiers that can be integrated with waveguide switches and multiplexers. Ideally, the fibers would be fluorocarbon based to minimize loss.

DESCRIPTION: Fiber optic networks require ever expanding orders of magnitude increase in signal carrying capacity and processing. Toward these ends, rare earth doped glass optical amplifiers have been developed, as optical signal transmission over multikilometer distances requires periodic signal amplification. Existing 1550 nm amplifiers (erbium-doped fiber amplifiers, or EDFAs) employ many meters of special erbium-doped glass optical fiber pumped by 980 nm diode lasers so that stimulated emission at 1550 nm occurs. The long path lengths are a consequence of the small concentration of erbium oxide achievable in glass fiber. Proposed efforts shall address erbium-containing polymers with a target concentration of 10^{21} ions/cm^3, sufficient to enable the fabrication of waveguide amplifier devices on a length scale of a few centimeters. Critical to performance is the erbium excited state lifetime, which must be at least one millisecond. In organic materials, the primary mechanism for lifetime shortening is the coupling of electronic energy into vibrational energy of the host material via overtone transitions. Material design and synthesis must be accomplished so that quenching is eliminated. The amplifiers should be compatible with network transmission rates in the range of 1-10 Gbps and provide gains greater than 10-20 dB. The amplification device should be compatible with commercial high-performance protocols. A ruggedized form of the amplifier should be capable of operating over the military temperature range.

PHASE I: Synthesize a thin film material by organic methods whose erbium ion concentration is on the order of 10^{21} ions/cm^3 and whose ion excited state lifetime is on the order of 1 ms. Demonstrate feasibility of a rare earth doped polymer optical amplifier to include evaluation of optical properties, gain, temperature performance, cost, size, and weight of the amplifier component. Evaluate the temperature performance of the amplifier. Evaluate and select a low cost protocol chip.

PHASE II: Develop and demonstrate a rare earth doped polymer optical amplifier prototype, including evaluation of gain, throughput, size, weight, power dissipation, and performance over the military temperature range.

PHASE III: Independently or with a major manufacturing corporate partner, develop fabrication methods suitable for low-cost manufacturing and production of rugged amplifier device components for use in commercial and military applications.

COMMERCIAL POTENTIAL: A large market is anticipated for polymer optical amplifiers for economical, high bandwidth voice, video, and data transmission.

KEY WORDS: optical fibers, amplifiers, rare earths, doping, polymer, erbium

N99-017 TITLE: A Large Area Hidden Corrosion Detection Device for Aircraft

SCIENCE/TECHNOLOGY AREA: Materials, Processes and Structures

OBJECTIVE: Develop a device for quickly and economically detecting hidden corrosion in multiple layer aircraft structures.

DESCRIPTION: Multiple layer structures, including repaired areas, tear straps, doublers, fuselage reinforcements, multi-layer joints, skin to core areas, and lap splice joints are common in Navy and commercial aircraft. Current techniques for detecting hidden corrosion in clean or painted multi-layer aircraft structures are expensive, time consuming, cover small areas (are essentially point-by-point), and are often unreliable and controversial in their indications. Crack detection is limited to the surface and second layer of a known structure. Recording defect images of a large area is possible, but the inspection setup is time consuming, equipment is expensive, analysis is difficult, and sizing and location analysis is unreliable. A simple, quick, inexpensive and reliable large area (as opposed to point-by-point) method of nondestructive testing of multiple layer structures is needed as a maintenance tool. The device should be capable of detecting thinned fuselage structures and hidden corrosion in multiple layer structures with as many as five layers having corrosion attack at any interface. The device should be portable, hand operated and capable of data and decision

logging. Complex scanning systems are undesirable for their size and/or potential operator training requirements.

PHASE I: Determine the basic physics and mechanics of the nondestructive evaluation of multiple layer aircraft structures. Demonstrate the feasibility of converting this technology into a simple, hand held inspection device.

PHASE II: Develop a working prototype inspection device. Evaluate device performance in terms of overall success in detecting different types of corrosion defects (i.e.: wall thinning, interface corrosion attack, inner or outer wall corrosion attack). Establish a database relating the inspection success rate to corrosion or defect type.

PHASE III: Under program office or industry sponsorship, conduct tests on a variety of different aircraft structures within the fleet.

COMMERCIAL POTENTIAL: A hand held inspection device with proven performance capability will have immediate application commercially. The aircraft industry will benefit in time and cost savings, as well as increased flight safety.

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KEY WORDS: Corrosion, inspection, aircraft, ultrasonic, nondestructive, joints

N99-018 TITLE: Formulation of Underwater Coating for Hull Touch-Up Repair

OBJECTIVE: Develop a polymer coating combination that will be immiscible with seawater and fresh water, and would be cohesive enough to not Atadpole or break away during application.

DESCRIPTION: Underwater hull paint touch up repairs are normally performed by divers. When applying the paint, it is normally done above the diver's head. The coating being applied would normally disintegrate or break away from the paint brush or application gun, thus contaminating the water, causing the water to becomes cloudy making it difficult for the diver to see and complete the mission. It would also contaminate marine life. This will not meet the EPA standard for clean water. Development of a new polymer combination would consist of no solvents (100% solids) and no heavy metals with good cohesive strength, and will have the ability to meet VOC requirements regulated by the Federal and State government. It would be user friendly, and not toxic site disposable. The transfer efficiency will need to be extremely high to meet these demands.

PHASE I: To develop a coating system using a modified epoxy with curing agent system, that may be of the polyamide and polyamine functional groups, that can be applied under water. If this system is proven to be feasible, it should be able to fill in pits in steel and repair any damage to steel underwater. It should also be capable of being painted over with a different coating system while in drydock.

PHASE II: Optimize the potential formulation developed and integrate the technology into a working pilot system for underwater hull touch up repairs.

PHASE III: The use of underwater hull touch up repair coatings could extend to all classes of ships and submarines.

COMMERCIAL POTENTIAL: This technology would show promise for use on commercial sea vessels as well as Navy vessels. The use of this technology would provide considerable cost savings in reduced drydocking time for hull paint touch up repairs. It could be used to touch up dock block areas on a vessel after it has been removed from drydocking.

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(1) Deep-Water Production Corrosion Technology; by R.D. Kane, S.T. Tebbal, M.S. Cayard, and H.R. Hanson; Materials Performance Magazine; April 1998, Volume 37, Number 4, page 54.
(2) Case Histories- Salt Water and Underwater; by Colin Allen; Corrosion Management Magazine; August 1995, Volume 4, Number 3, page 8.

KEY WORDS: Environmental, clean water, dock block, drydock, underwater coating, non-contamination.

N99-019 TITLE: Actuators and Transducers from Single Crystal Piezoelectric Materials

SCIENCE/TECHNOLOGY AREA: Materials

OBJECTIVE: Use single crystal piezoelectric materials for high performance acoustic transducer and electromechanical actuator applications.

DESCRIPTION: Recent research results have established that relaxor-based single crystal piezoelectric have exceptional performance characteristics compared with conventional alternatives for acoustic transduction and electromechanical actuation, for example, electromechanical coupling exceeding 90%. These materials promise enhancements of more than an order of magnitude for broadband sonar and medical diagnostic transducers, and for electromechanical actuators that are used in vibration control applications, especially aboardships. To utilize these single crystals, cost-effective innovative device design and fabrication methods are sought which will produce transducer and actuator applications with revolutionary performance; e.g., targeting bandwidth increase in excess of one octave and a strain level of 0.5% for the expansion of bandwidth of existing transducers, miniaturize current devices to provide high power sources or vibration control for signature reduction.

PHASE I: Demonstrate a device design and prototype fabrication that make use of piezoelectric single crystals with high electromechanical coupling and high actuator authority.

PHASE II: Develop a cost-effective device fabrication method and demonstrate performance in prototype device configurations.

PHASE III: Manufacture acoustic transducers and electromechanical actuators to be incorporated into a current Naval system, and demonstrate the revolutionized high performance over current systems or miniaturize the current systems.

COMMERCIAL POTENTIAL: These high performance devices will have application as broadband ultrasonic transducers used in medical diagnostic imaging, and as high strain electromechanical actuators used for vibration control in air conditioners, automobiles, and aircraft.

REFERENCES: Seung-Eek Park and Thomas R. Shrout, "Characteristics of Relaxor-Based Piezoelectric Single Crystals for Ultrasonic Transducers," IEEE Transactions on Ultrasonics Ferroelerctrics and Frequency Control, Vol.44, No. 5, 1140-1147 (1997).

KEY WORDS: Piezoelectric; Single Crystal; Acoustic Transducers; Electromechanical Actuators; Relaxor Ferroelectrics; Ultrasonic Transducers

N99-020 TITLE: Active Control Using Microelectromechanical Systems (MEMS)

SCIENCE/TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop and demonstrate active flow control systems using micro-sensors /actuators and electronics.

DESCRIPTION: Active control approach to reduce noise and vibration has received a great deal of attention and has achieved a certain level of practicality. Recent advances in control algorithms, MEMS-based sensors, actuators, and electronics further provide the control community an opportunity to tackle the more challenging flow control problems. Examples include flow control around airfoil, stator wake management in rotating machinery, and control of shear layer in jet flow, etc. The success of flow control provides enhanced performance and reduction of high cycle fatigue in rotating machinery. Furthermore, MEMS technology provides miniaturization of the active control system, which has potential to reduce the cost and weight of the overall active control systems.

PHASE I: Feasibility Study: Examine various novel micro-sensor/actuator devices, electronics, and robust control algorithms; and develop an active flow control concept. Based on results from the feasibility study, select application(s) for further development and demonstration.

PHASE II: Develop and demonstrate active flow control systems. These efforts will be conducted in the laboratory with prototype models for the application(s) selected in PHASE I.

PHASE III: Transition MEMS-based active flow control methodology to practical and engineering problems.

COMMERCIAL POTENTIAL: The commercial applications include flow control devices/components in rotating machinery, such as aircraft engines, compressors and pumps, as well as aircraft flaps and wing, and helicopter rotary blades. Most important, this SBIR effort develops a design process to miniaturize active control systems, which has positive impact on the cost, size, and weight of the control systems.

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5. Miller, M. B., et al., "Optical Fiber-Interconnected MEMS Sensors and Actuators," Proceedings of the 5th SPIE International Symposium on Smart Structures and Materials, Vol 3330, March 1998.

KEY WORDS: active control; MEMS; micro-sensors; micro-actuators; flow control; adaptive structures and systems

N99-021 TITLE: Fuels for Pulsed Detonation Engines

SCIENCE/TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop methods for synthesis of new fuels, chemical modification of conventional fuels or energetic fuels that can be dissolved in conventional fuels, specifically suited for use in pulsed detonation engines (PDE).

DESCRIPTION: Pulse detonation engines offer the capability of propelling weapons for subsonic to supersonic speeds without ejecting boosters, and with fewer moving parts. Development of the science and technology base for PDE has been initiated. A number of traditional fuels and oxidizers have been tried in PDEs; Gas fuels perform adequately in engines, but are not amenable to weaponization. Liquids have the energy and density characteristics that make them candidate for PDE fuel and provide cooling for the PDE detonation tube. New fuel or fuel formulations are required to meet the challenges offered by PDEs, such as good volumetric energy density, provision of endothermic cooling, quick vaporization and mixing with air, and most importantly, detonation without a long detonation tube.

PHASE I: Develop synthesis methods for new fuel and fuel formulations that are amenable to detonation. Develop fuels that will dissolve in conventional fuels and enhance detonation characteristics.

PHASE II: Develop methods for large-scale synthesis or production of the new fuel(s), fuel formulation(s) or fuel additive(s). Perform laboratory scale detonation characterization in actual PDE tube.

PHASE III: Develop demonstration plant technology for the production of selected PDE fuel, fuel formulation or additive.

COMMERCIAL POTENTIAL: Stationary PDE technology for electric power generation have been discussed. The developed product could be used in such systems.

KEY WORDS: Detonation, high energy fuel, vaporization, propulsion

N99-022 TITLE: Self-Contained Pumps and Machinery

SCIENCE/TECHNOLOGY AREA: Propulsion and Power

OBJECTIVE: Develop self-contained pumps based on the use of newly developed Active materials (Smart materials) concepts.

DESCRIPTION: Active (Smart) materials offer a unique opportunity for developing self-contained pumps for various Navy and civilian applications. Recent developments in active materials such as those activated by magnetic or electric fields, are providing phenomenal activation strains at very high frequencies. The combined high frequency and high strain could be utilized in developing new pumps with unique properties. The efficiency of such self-contained pumps could also be very high because of the elimination of traditional design constraints. Due to the reduction of the number of moving parts and the high operating frequency they would generate very low noise. Active (smart) materials are a class of materials, which have the capability to both sense and respond to environmental stimuli. Previous DOD programs have provided theory, design tools, characterization of collective behavior and integration technology. These programs also fostered development of the active constituents such as shape memory alloys, electrostrictive ceramics, magneto-stricitve alloys, magneto memory alloys, and fiber optic sensors. Self-contained pumps should exploit revolutionary concepts of direct electro or magneto-hydro mechanical energy conversion. Several concepts of application of smart materials in MEMS type pumps, may also prove applicable to large size pumps. Innovative new actuators (linear, torsional,

continuous, ratcheting, inchworm, bimorph, flextension and other concepts including multi-axis actuators) which exploit the unique properties of active (smart) materials or a composite/hybrid of active materials could be the basis for developing self-contained pumps. This technology could provide highly compact pumps, with high reliability, efficiency and controllability. Interest is in self-contained pumps for performing various functions currently performed by various types of positive displacement pumps.

PHASE I: Develop several concepts for self-contained pumps, integrate active materials (smart materials) and demonstrate functionality.

PHASE II: Down select and build prototype self-contained pump and investigate efficiency, acoustics and other operational parameters.

PHASE III: Refine efficiency and develop program for practical cost effective application to a wide range of fluids, pressures, flow rates and acoustic parameters.

COMMERCIAL POTENTIAL: In addition to Navy ships and submersible applications, self-contained pumps should have a tremendous market in automotive (e.g. fuel pumps, power steering pumps, brake booster pumps), passenger aircraft, aerospace, and marine systems, and the chemical and petroleum industry. A potential civilian application could be in artificial heart pumps, medicine delivery (probably MEMS) and other medical devices.

REFERENCES: SPIE Annual International Symposium on "Smart Structures and Materials" held in San Diego CA, Proceedings, March 1996, 1997, 1998.

KEY WORDS: Self-contained pumps, actuators, smart materials, active materials, magnetostricitve materials, Terfenol, piezo-ceramics, PZT, shape memory alloys, magnetic memory alloys.

N99-023 TITLE: Standardized Interconnect Technology for Integrated Power Modules and PEBB

SCIENCE/TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop an interconnect system containing standardized bus bars that enables a `snap together' approach taking standard power electronic components and subsystems and assembling them into a fully operational three PHASE system such as an Inverter, motor controller, converter or power supply.

DESCRIPTION: Power Electronics technology is characterized by application specific systems development resulting in significant engineering costs embedded in each new power electronics product. The focus in power electronics has been in the development of discrete components optimized for cost, performance and market. To address this situation, an new IEEE standards committee(1) has developed "recommended practices" to address the integration of components, subsystems, power electronic modules and systems via interconnections .

PHASE I: Design and Develop an integrated bus bar system that is suitable for integrating all the components that go into making up a three - PHASE Inverter between 30 to 100 kW. Show how this approach can be used to optimize performance and minimize and reduce total system input impedance. Show how this meets and exceeds the recommended practices of IEEE 1461-Power Electronic Module Interfaces.

PHASE II: Develop, characterize and test a 3-PHASE Inverter of 100 kW using standard power electronics components and modules based on the bus interconnect technology. Develop and incorporate a communication system for internal and external control of the power electronics and the control electronics.

PHASE III: Design, Demonstrate and Fabricate fully function power electronics systems between 30 and 250 KW using the above concepts that integrate all the above approaches from commercial off the shelf and PEBB module components. Demonstrate multifunctionality, programmability and "plug and play" capability with a suitable user interface.

COMMERCIAL POTENTIAL: This system can be applied to any power electronics environment from motor controls to the power utilities. This proposal will enable the development of low cost high density integrated power electronic module systems (PEBB)

REFERENCES:
1) IEEE Standards Committee 1461; Power Electronic Module Interfaces; http://grouper.ieee.org/groups/1461/index.html
2) PEBB WEB SITE: pebb.onr.navy.mil

KEY WORDS: interconnection, bus bar, power electronics, PEBB, "plug and play"

N99-024 TITLE: Nondestructive Evaluation of Composite Core Structures

SCIENCE/TECHNOLOGY AREA: Materials and Processes

OBJECTIVE: Develop a nondestructive inspection technique to detect delaminations, disbonds, and foreign material in composite core structures.

DESCRIPTION: In order to achieve weight savings and signature reduction, the US Navy is increasing the use of multi-layer composites in the super structure of surface ships, for example, the AEM/S system and LPD-17. For structural strength, these composites often contain multiple balsa wood or polyurethane form cores with glass reinforced laminates ; e.g., E-glass woven rovings in polyester resin. Traditional NDE techniques, ultrasonic and radiography, are unable to detect critical size voids, disbonds, kissing disbonds, delamination (50-300 mm in panels, 5-50 mm in T and top hat joints), and porosity at the skin-to-core bond lines. Furthermore, no current inspection technologies can inexpensively and reliably penetrate to inner layers of the foam and wood structures for inspections. Thus, the Navy requires a reliable technique for inspection large section layered composites.

PHASE I: Investigate techniques to perform detection of delamination, disbonds, kissing disbonds, and porosity in multi-layered composites. Identify limitations of techniques as applied to in-the-field inspections.

PHASE II: Develop prototype inspection equipment and quantify limitations of hardware. Develop inspection procedure. Identify resolution (minimum size detectable) of technique for disbonds, kissing disbonds, delaminations, and porosity. If possible, the developed technique should identify the layer (depth) at which the defect is located.

PHASE III: Transition the inspection equipment to the Navy, for example, the Norfolk Naval Shipyard and the Naval Surface Warfare Center, where the system can be demonstrated on the AEM/S system and/or LPD 17. Train Naval personnel on the inspection technique.

COMMERCIAL POTENTIAL: This technology has direct application to commercial shipyards, for example, Bath Ironworks, Avondale Industries, General Dynamics, and Ingals Shipyard. In addition, this technology is applicable to inspection of composite structures aboard aircraft at Boeing, and Lockheed Martin.

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4. J. Sumpter, "Defect Tolerance of GRP Ships," International Conference Advances in Marine Structures III, Session 4, Paper 12, DERA Rosyth, UK 20-23 May 1997.

KEY WORDS: thick-section composite, core structures, disbonds, delaminations, nondestructive evaluation, composite joint inspection

N99-025 TITLE: Medical Data Fusion Watchboard

SCIENCE/TECHNOLOGY AREA: Computers/Software

OBJECTIVE: Enable medical care providers, support personnel, and remote command to fuse casualty related data within a medical treatment facility to track casualty movement and assess the medical situation.

DESCRIPTION: A number of efforts are underway developing personnel status monitors capable of alerting medical resources if the soldier's vital signs indicate an injury. Other devices are available which could be used to track the movement of casualties within a medical treatment facility. In addition, there are a host of other data available that are relevant to medical care and medical readiness. This effort would fuse this information on a real-time electronic watchboard, so that medical care providers, support personnel, and remote command locations could visualize the medical care situation. This type of visualization tool could be used to help allocate medical and support resources to the most appropriate locations.

PHASE I: Identify the types of information available from various personnel monitoring devices and databases. Create

a proof of concept prototype watchboard that displays a floor plan, shows the location of each casualty, and provides mechanisms to access casualty relevant data.

PHASE II: Work with users to design the specific user interface. Provide support to import and use pre-drawn CAD files. Provide the capability to add various annotations to the floor plans and allow the user to simultaneously display multiple types of casualty data. Add the ability to generate and display summary information. Define a set of test scenarios varying the location, status, and number of casualties. Develop and test the Data Fusion Watchboard in concert with medical care providers and medical planners. Where appropriate, implement live connections to data required by the system.

PHASE III: Produce graphical front ends tailored to medical care providers and medical planners (DoD/Commercial). Integrate with existing military and civilian systems.

COMMERCIAL POTENTIAL: This system could be used by civilian medical care facilities and local resource planners.

KEY WORDS: Medical; Data Fusion; Patient Tracking; Watchboard; Planning; Real-Time

N99-026 TITLE: A Case Resource for Cognitive Task Analysis

SCIENCE/TECHNOLOGY AREA: Manpower and Training Systems

OBJECTIVE: Provide a computerized resource of case examples of cognitive task analyses to aid users in addressing new task analysis problems.

DESCRIPTION: The changing nature of modern work gives increasing importance to the mental or cognitive aspects of jobs that cannot be directly observed and analyzed by others. Consequently, for purposes of training design, the effective design of computer systems to support work, task allocations to team members and related applications, "cognitive task analysis" is increasingly needed. A NATO Study Group on Cognitive Task Analysis has concluded that the state of the art is not consistent with any cut-and-dried prescriptive or textbook approach to cognitive task analysis. Typically, a successful and useful cognitive task analysis involves a complex orchestration of several research techniques to obtain the necessary information to support the target application. It is felt that the most useful aid to those faced with a need to conduct a cognitive task analysis would be a convenient resource providing access to cases of prior cognitive task analyses that were considered successful in achieving the desired result. Users could identify past cases similar to their own problem in dimensions such as the domain of application (eg. Maintenance, tactical decision-making, navigation), the type of application (training, system design, certification of competence) and the human and financial resources available. Drawing upon upon related past cases, users could then develop a plan for their own cognitive task analysis problem, applying a case-based reasoning approach. Ideally, the case resource to be developed under this project would be computerized and provide access to the full text of articles, books, or book chapters describing the cases; the design should provide for continuing updates through the addition of new cases.

PHASE I: Conduct research to determine appropriate indexing categories and/or dimensions for cases. Conduct research to locate prospective cases of cognitive task analyses, aiming to accurately estimate the total size of the currently available population of cases. Design and prototype the case resource tool and investigate the feasibility and cost of obtaining rights to the full descriptive texts. Investigate the availability of computer aids to aspects of the cognitive task analysis process and investigate the feasibility and cost of obtaining rights to incorporate such tools in the resource.

PHASE II: Develop the case resource tool. Test with a sample of prospective users and refine appropriately. Assess helpfulness and market potential of cognitive task analysis case resource.

PHASE III: Further develop as necessary for commercialization and commercialize.

COMMERCIAL POTENTIAL: This product should have modest commercial potential if appropriately marketed to academics and consulting firms in the areas of industrial psychology and system development. Increasing demand for cognitive task analyses is to be expected from both DoD and commercial industrial customers. Their contractors are going to need the assistance of a resource such as this to meet the growing demand.

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KEY WORDS: cognitive task analysis; task analysis; user-centered design; instructional design; case-based reasoning; knowledge engineering; expert systems.

N99-027 TITLE: User-friendly techniques for creating realistic models of Human Behavior Under the Stress of Battle

SCIENCE/TECHNOLOGY AREA: Modeling and Simulation

OBJECTIVE: The objective is to develop efficient, user-friendly techniques that can be used to extend and exploit current models of human cognition and performance to create computer generated forces (CGFs) that respond realistically to sources of battle-related trauma (e.g., suppressive fire, biological or chemical weapons, ionizing radiation, psychological stress) in distributed interactive simulations for military training and analysis.

DESCRIPTION: A major requirement for conducting effective training or analysis with distributed interactive simulations is to exercise with and against realistically behaving CGFs. Today's CGFs do not respond in the same way or with the same variability as do real combatants operating under the stresses of battle. Consequently, virtual or constructive simulations populated with currently available CGFs provide training of limited effectiveness and analytical results of limited validity. Preliminary demonstrations have shown that stress sensitive CGFs (SSCGFs) can be created (Pew and Mavor, 1998). What is now needed is the creation of techniques for generating SSCGFs that (1) are efficient and user-friendly; (2) enable the principled linkage of stress effects to specific cognitive and perceptual operations; (3) produce realistic ranges and types of variability in responses to stress across simulated individuals differing in training, experience, and other stress moderators; and (4) are extendable across a selected range of stressor types.

PHASE I: Based on a thorough understanding of the empirical and theoretical literatures on cognition and human performance and on the effects of stress on human behavior and on perceptual and cognitive operations, develop a conceptual framework for understanding human performance degradation under high stress. The framework must incorporate abilities, tasks, and behavior descriptions, and identify cognitive and perceptual sub-processes and behavioral outcomes effected by identified stressors. The framework must be compatible with DMSO's High Level Architecture and should exploit developments in its program on Conceptual Models of the Mission Space.

PHASE II: Use the framework developed in PHASE I to extend and exploit an existing model of human cognition and performance such as Soar, COGNET, ACT-R, or other executable model to create SSCGFs in both a combat operations and a decision making mode within a distributed interaction simulation environment proof-of-concept exercise, using selected stressors. Provide an assessment of the effectiveness of the resulting model with respect to its ease of application (user friendliness) and the realism of the nature and variability of stress effects it exhibits in the exercise, and modify the model as required to address identified usability and validity problems.

PHASE III: Apply and quantitatively evaluate the model emerging from PHASE II in a major distributed interactive simulation exercise within the Joint Countermine Operational Simulator (JCOS)/Extending the Littoral Battlespace (ELB)/Joint Medical Operations-Telemedicine combined ACTD demonstration.

COMMERCIAL POTENTIAL: When completed, SSCGF development software will provide the basis for creating synthetic entities that are responsive to the effects of a selected set of battlefield stressors. This accomplishment opens the door to simulating human responses associated with other highly stressful situations such as nuclear power or chemical plant operations, commercial aircraft operations, air traffic control, hostage negotiations, and natural disaster response. SSCGF extensions will enable modelers to account for fatigue, confusion, anger, and fear, which have hitherto not been represented in combat or disaster simulations. In addition, the use of SSCGFs in entertainment games and virtual reality arcades will make the computer driven opponents more exciting to confront.

REFERENCES:
1. Pew, R.W & Mavor, A.S. (Eds) Modeling human and organizational behavior: application to military simulations. Final report of the NRC Panel on Modeling Human Behavior and Command Decision Making: Representations for Military Simulations, 1998.
2. Fineberg, M.L. Sensitizing synthetic forces to suppressive fire on the virtual battlefield. Proceedings of the Sixth Conference on Computer Generated Forces and Behavioral Representation, Orlando, FL, 1996.

KEY WORDS: Stress; cognitive modeling; CGFs; DIS; simulation for training; battle injury.

N99-028 TITLE: Prognostics for Electric Actuation Systems

SCIENCE/TECHNOLOGY AREA: Aerospace Vehicles

OBJECTIVE: To develop new technologies for predictive diagnostics of next generation electric actuation systems (including the actuators, the control and power electronics, and the power management and distribution system)

DESCRIPTION: Electric actuation has currently reached the level of technical maturity that it may be used in military aircraft in the near future. The move to electric actuation will create new challenges in diagnostics and prognostics technology such as the increased integration between the flight control, electric power, and cooling systems. At the same time, increases in the amount of data that is available on-line and advances in prognostic technology make prognostics or predictive diagnostics an important technology to develop to predict and isolate failures for this type of system. The focus of this program should be on developing new software algorithm solutions such as neural networks, fuzzy logic, advanced statistical pattern recognition, model-based systems, and expert systems as opposed to adding additional sensors to current designs. Any proposed sensor technology must be low-cost, low weight, and low volume (e.g., micromechanical sensors). Another factor of importance should be avoiding false alarms.

PHASE I: The proposed prognostic technology shall be developed and demonstrated either in simulation or on available laboratory or flight test data for electric actuation system hardware components.

PHASE II: The contractor shall do additional technology development and design a software package to implement and test prognostic algorithms for electric actuation systems. The contractor shall perform a laboratory demonstration to show the ability of the algorithms to predict and isolate failures. This demonstration shall utilize, to the greatest extent possible, actual flight control hardware. Demonstration of the prototype system using a simulated data stream in lieu of actual hardware data will be considered marginally acceptable.

PHASE III: PHASE III will demonstrate the prognostic algorithms in a flight test program.

COMMERCIAL POTENTIAL: Electric actuation is currently being developed for a wide range of applications including aircraft, ground vehicles, robotic, and manufacturing. There is currently a strong demand for techniques that can predict failures in electric actuation hardware without the addition of expensive sensor technology. As a result, the software package should have strong commercial potential, if successful.

REFERENCES: More Electric F-18 Cost Benefit Study, Air Force Report: WL-TR-91-2093; Lessons Learned in Electrical Actuation Development for Flight Control Systems, Air Force Report: WL-TR-97-3069

KEY WORDS: prognostics; flight control; electric actuation; diagnostics

N99-029 TITLE: Fault-Tolerant and Intelligent Flight Control for Multiple Correlated Failures caused by Man-Portable Air Defense Systems (MANPADS)

SCIENCE/TECHNOLOGY AREA: Aerospace Vehicles

OBJECTIVE: To develop advanced technologies for fault-tolerant, intelligent, and reconfigurable flight control systems that can deal with multiple correlated failures caused by Man-Portable Air Defense Systems (MANPADS).

DESCRIPTION: Much of the fault-tolerance of current flight control systems is based on an assumption of random independent single failures that occur at different times. Similarly, much research work in intelligent and adaptive control has limited ability to deal with multiple simultaneous failure cases (e.g., simultaneous damage to a flight control surface combined with degraded sensor information). In contrast, the growing threat of Man-Portable Air Defense Systems, like SA-16's and Stinger missiles may cause multiple correlated failures in the flight control system. Multiple correlated failures may cause loss of aircraft despite the fact that the same combination of failures occurring at different times due to different causes would not cause loss of an aircraft. For example, in a triplex control system, it is possible that a multiple correlated failure would cause 2 degraded channels to vote out the single remaining healthy channel and cause a loss of aircraft and aircrew. This is a particularly challenging problem since there is so little theory to deal with this type of problem. Potential approaches to this problem could include adaptive control, robust control, intelligent control (such as neural networks and fuzzy logic) or advanced sensor technology. Theoretical development of approaches to identifying vulnerability for multiple correlated failures will also be necessary. This technology could also be used to deal with

other potential causes of multiple correlated failures like a thrown turbine blade or mid-air collision.

PHASE I: The contractor shall develop and demonstrate their technology approach towards reducing the vulnerability of flight control systems to multiple correlated failures. This shall include limited simulation of algorithms and hardware approaches.

PHASE II: The contractor shall perform additional development of vulnerability reduction technologies and demonstrate the approaches to vulnerability reduction using high fidelity simulation and possibly either piloted simulation or limited real-time hardware in-the-loop laboratory demonstration. The contractor shall publish a design handbook for the application of these technologies to flight control systems and a an accompanying software package to implement an algorithm techniques.

PHASE III: The contractor shall do extensive piloted simulation and laboratory hardware-in-the-loop demonstration of the vulnerability reduction technologies.

COMMERCIAL POTENTIAL: There is currently concern within the commercial aviation community about the threat of MANPAD systems used by terrorists. This technology could also be used to deal with other potential causes of multiple correlated failures like a thrown turbine blade or mid-air collision. The ability to diagnose multiple correlated failures would also be of value in other industries with safety-critical control systems like the nuclear power industry.

KEY WORDS: flight control, vulnerability, multiple correlated failures, MANPADS

N99-030 TITLE: Adaptable Explosive Composition

SCIENCE/TECHNOLOGY AREA: Conventional Weapons

OBJECTIVE: To develop an energetic material having a controllable rate and magnitude of energy release.

DESCRIPTION: A need exists for an energetic material whose energy release rate and magnitude can be controlled to provide either high internal blast or high metal acceleration or muted output. This material is needed in conjunction with an adaptable ordnance technology program intended to develop a single ordnance package having capable of producing multiple kill mechanisms.

PHASE I: Generate concepts and mathematical models of candidate energetic materials. The use of multiple low energy detonators may be necessary to achieve variable output.

PHASE II: Formulate, synthesize and characterize small batches of adaptable explosive. Demonstrate adaptable output using small-scale hardware. Scale-up successful compositions to evaluate and identify production issues. Demonstrate accuracy of predictive mathematical models

PHASE III: Qualify successful compositions for DOD and Navy use. Transition data package to industry.

COMMERCIAL POTENTIAL: Technologies demonstrated under this effort have applications to commercial blasting, automotive airbags and universities study detonation physics.

KEY WORDS: explosives, energetic materials, internal blast, metal acceleration, collateral damage control, low energy initiators

N99-031 TITLE: Multiple Separable Penetrators

SCIENCE/TECHNOLOGY AREA: Materials, Processes and Structures

OBJECTIVE: To develop technologies enabling multiple separable penetrators to function as a single penetrator assembly.

DESCRIPTION: A need exists for multiple rigid penetrators to be interlocked into a single large penetrator, as well as being easily separated from the large penetrator into discrete penetrators. This must be achieved using techniques and technologies that minimize the parasitic weight and component costs. There are no other restrictions to the approach taken. Novel mechanical and non-mechanical approaches are encouraged.

PHASE I: Generate concepts and demonstrate proof of principal using simplified hardware.

PHASE II: Develop and characterize the requisite technologies using full or subscale hardware. Develop and verify the accuracy of structural analysis tools to describe the penetration and separation mechanics.

PHASE III: Transition technology to Missile and Projectile program offices for potential inclusion in next generation penetrating weapons.

COMMERCIAL POTENTIAL: Technologies demonstrated under this effort will likely have applications to material joining and

separating needs found in the space and automotive industries. This will create new markets for these types of technologies in the small business materials and electronics sectors.

KEY WORDS: Joining, separating, penetrators, materials, modeling, control

N99-032 TITLE: Prediction of Structural Response to Fragmentation/Blast/Firestarting Effects

SCIENCE/TECHNOLOGY AREA: Conventional Weapons

OBJECTIVE: To develop accurate analytic models and tools for predicting the damage to surface targets caused by novel warhead concepts.

DESCRIPTION: A need exists for accurate models to predict the effectiveness of novel warhead concepts against the evolving set of threat surface targets such as vehicles, equipment or buildings. Current analytic tools have little or no capability to predict the effect of new or little understood kill mechanisms. Specific kill mechanisms of interest include fire, synergistic effects from focused fragmentation, internal blast and shock against current and next generation threat surface targets.

PHASE I: Quantify the shortcomings of current analytic models as regards new kill mechanisms and next generation targets. Generate new physical and/or semi-empirical models to describe new kill mechanism lethality and target response phenomenon.

PHASE II: Quantify the accuracy of the new performance models by comparing predictions to actual experimental data. Database for new kill mechanisms and next generation targets will have to be developed anew.

PHASE III: Develop computer coding required for performing large-scale performance predictions in an efficient manner. Transition code to industry.

COMMERCIAL POTENTIAL: Internal blast damage prediction models will be applicable to commercial aircraft industry as they endeavor to design bombproof baggage storage compartments. In addition, these blast models can be used to enhance current models used in the design of aboveground and underground buildings which must withstand blast damage. Examples of these structures include office buildings, airports, and residential structures in high risk areas. Firestarting models will be applicable to fire protection and arson reconstruction industries. Finally, the shock models will be applicable for industries which must design equipment to survive shock transmissions.

KEY WORDS: target interaction, lethality, vulnerability, firestarting, internal blast, modeling, shock

N99-033 TITLE: Radiation Hardened Wide Bandgap High Poser High Power DC-DC Converters for Space Applications

SCIENCE/TECHNOLOGY AREA: Electronics

OBJECTIVE: To combine recent research efforts in wide bandgap materials and devices in order to develop DC-DC converters for space-based applications requiring greater than 1kW loads. Radiation tests on the prototype will provide benchmark data on wide bandgap technologies.

DESCRIPTION: Space propulsion, space radar and other power applications require reliable, and efficient DC-DC converters operating at power levels exceeding 1kW. Recently, in the radiation effects field, power devices have shown permanent damage effects due to single ionizing particle radiation. Additionally, technologies utilizing gate and field oxides incur total dose effects due to charge trapping. Recent advances in the wide bandgap materials and devices (GaN, Sic, GaAs, etc) may provide improved efficiency and radiation hardness for power applications in space environments. It is desired that the converter be immune to single event effects such as SEGR, SEB, SEL and total dose levels above 1 Mrad. This work should benefit Navy research programs developing compact power converters with wide bandgap technology.

PHASE I: Formulate initial concepts, propose circuit designs and specify a semiconductor foundry to provide a radiation hard controller for the DC converter. Identify possible suppliers of power devices and confirm radiation hardness of controller IC technology.

PHASE II: Fabricate the controller IC. Provide thorough radiation tests with heavy ions and protons showing immunity. Demonstrate a DC-DC prototype converter utilizing wide bandgap power devices and document a capability to attain at least 1kW operation for PHASE III studies. The prototype should provide improved characteristics over present high-power converters.

PHASE III: Transition the successful hardened prototype to a commercial product. Identify a space platform and

formulate a space experiment for the prototype design.

COMMERCIAL POTENTIAL: The need for ion propulsion thrusters requiring in excess of 1kW of power may be common place in the near term. The development of a completely radiation immune DC-DC converter that is efficient would be a very attractive product for the hundreds of planned commercial satellite constellations.

REFERENCES: There is considerable work on DC-DC converter designs in several IEEE journals. Very little documented research exists addressing radiation effects on the wide bandgap materials. Information on radiation effects in power devices such as SEGR, SEB and SEL can be found in the IEEE Transactions on Nuclear Science. For additional documentation, contact TPOC listed below.

KEYWORDS: space power, semiconductors, radiation hardening, Gallium Nitride, Silicon Carbide, power electronics

N99-034 TITLE: Intrinsic Earth Surface Material Classifier

SCIENCE/TECHNOLOGY AREA: Software

OBJECTIVE: Provide a system to process sensor data into permanent earth surface physical descriptor codes from which reliable and accurate sensor signatures can be generated.

DESCRIPTION: The utility of remote sensing measurements are severely limited by the unavailability of a common permanent surface material classification system. This deficiency limits the fusion, comparison, and analysis of measurements taken by different sensor systems, as well as similar sensor systems taken at different times. Classifications in use today tend to be locally calibrated and project-specific. Since spectral signatures generation can be factored into intrinsic permanent material properties and temporary environmental conditions, a system which provides classification and mapping of the permanent component of the earth surface materials is desirable.

PHASE I: Provide an approach and design for the development of a hierarchical classification system of earth surface materials properties pertinent to spectral signature calculations. The approach should: (1) consider abundance and the importance of the materials selected; (2) contain sufficient differentiation of spectral signatures to allow unambiguous classification within the resolution of the classification scheme; (3) provide a table of standard physical properties for each category, and (4) a model for calculating spectral modification due to temporal environmental factors.

PHASE II: Implement a prototype software system which implements the design developed in PHASE I. This PHASE should include the purchase and delivery of a PC based system. The system will utilize sensor spectral and environmental data registered to earth surface locations and provide surface material classification, error probabilities, and a list of likely alternatives. The classification index will be keyed to standard physical properties tables and be capable of generating expected spectral response at other wavelengths and environmental conditions.

PHASE III: The contractor is expected to incorporate the tools developed in PHASE II in order to reduce Ortho-photo, visible, IR, IFSAR, etc., data sources to produce high resolution (1 meter) earth material maps on demand and provide a growing library of surface material classification maps at low (100 meter) resolution. Such data will be provided in standard machine readable formats to facilitate computer utility.

COMMERCIAL POTENTIAL: The availability of intrinsic earth surface material classification systems will support Remote Sensing Data Reduction, GIS Systems, and Earth Resource Repositories. Both the establishment of service bureaus and the direct sales of software tools are envisioned.

REFERENCES: AGlobal Terrain Database Design for Realistic Imaging Sensor simulation, W. Baer, 13th DIS Workshop on Standards for the Interoperability of Distributed Simulations, Vol. I, Sep. 18-22, 1995, Orlando, FL., p. 19.

KEYWORDS: remote sensing; land classification; terrain database generation; spectral signatures; reflectivity modeling.

N99-035 TITLE: Electrohydrodynamic (EHD) Enhancement of Heat Transfer Surfaces

SCIENCE/TECHNOLOGY Area: Science

OBJECTIVE: Investigate the use of electrohydrodynamics for the improvement of heat transfer in liquid/liquid and liquid/air heat exchangers and quantification of potential material weight reduction.

DESCRIPTION: Recent laboratory research has shown that surface heat transfer may be significantly enhanced by the application of electrohydrodynamic (EHD) phenomenon to heat transfer surfaces/heat transfer fluids. EHD works through the application of a high-voltage electrostatic potential field across a heat transfer fluid. The applied electric field serves to destabilize the thermal boundary layer, increasing heat transfer near the heat transfer surface, and producing better mixing of the bulk fluid flow. The net effect is to increase the heat transfer fluid film coefficient, which may result in reduced heat exchanger weight/volume.

Initial EHD laboratory experiments have focused on liquid/liquid heat transfer with the following fluids: refrigerants, including R-123, R-134a, and R-11/Ethanol mixtures, PolyAlphaolenfin, and aviation fuel (JP-8). Although results from these experiments appear promising, the EHD technique required further innovation to address technical obstacles before it will find application. These obstacle include: evaluation of fluids with broader application (e.g. air), development of EHD heat exchanger/electrode design techniques and architectures, potential affect of decomposition of working fluids, research on heat exchanger materials compatible with EHD, and manufacturing process for incorporation of electronics. Additionally, a potential attribute of EHD which has not been explored, but could have military significance is the ability to develop active heat exchangers whose heat transfer capacity can be controlled and modulated. The goal of this project is to solicit innovative approaches that can address current technology deficiencies and result in heat exchanger designs which offer reduced size and weight over the current state-of-the-art technology.

PHASE I: Evaluate the existing AAAV heat exchanger uses and identify candidate applications on the basis of possible weight/size reduction. Investigate combinations of heat transfer fluids, materials, surface geometries, electrode sizes and arrangements, and develop design concept(s). Design concepts shall be supported by models, calculations and published research conducted by the vendor or others. Where needed, basic experiments will be conducted to validate the analytical approach. Additionally, the vendor must address the AAAV operating environment, technology barriers, potential impacts (if any) on material corrosivity and electromagnetic interference, and power conditioning/requirements. Results from PHASE I should clearly point to the best candidate(s) application to be pursued under PHASE II and should predict potential benefits (size, weight, and costs) of the EHD technology to the AAAV program.

PHASE II: Conduct any needed laboratory subscale heat exchanger analysis/experimentation to support EHD heat exchanger development and fabrication. Fabricate prototype(s) and demonstrate the performance characteristics of the EHD heat exchanger through a suitable test stand simulating design thermal loads. Results of PHASE II must clearly demonstrate the performance of the EHD heat exchanger, assess EHD technology maturity and applicability to the AAAV. Additionally, producibility of the EHD heat exchangers must be explored and demonstrated to the greatest extent possible. Potential benefits identified under PHASE I should be readdressed.

PHASE III: The system could be applied to any platform that would benefit from a smaller, lighter weight heat exchanger. Potential customers include the military as well as the aerospace and automotive industries.

COMMERCIAL POTENTIAL: The EHD technique promises high payoff potential for commercial applications such as liquid-cooled avionics, aircraft and automotive environmental control systems, oil and fuel heat exchangers, and potential application in thermal management systems. Industries that may receive immediate benefit from EHD include transportation, aerospace, commercial heat exchanger equipment for refrigeration and air conditioning, electronics cooling, cryogenic and laser medical/industrial cooling.

REFERENCES:

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2. Singh, A., M.M. Ohadi, S. Dessiatoun, M. Salehi, W. Chu, 1995, "In Tube Boiling Enhancement of R134a Utilizing the Electric Field Effect," 4th ASME/JSME Thermal Engineering Joint Conference: Vol. 2, pp. 215-223.
3. Yabe, A., 1992, "Experimental Study of Electro-hydrodynamically (EHD) Enhanced Evaporator for Non-azeotropic Mixtures," ASHRAE Transactions, Vol. 98, Pt. 2, pp.445.
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5. Ohadi, M.M., S. Dessiatoun, A. Singh, 1993, "EHD-Enhancement of In-tube Boiling of Alternate refrigerant/Refrigerant Mixtures," DOE Quarterly Report, September 1993, December 1993 and March 1994.
6. Air-Conditioning Research Institute (ARI), "Electrohydrodynamics Heat Transfer," Research and Technology News Update, January 1996.
7. Conversations with Dr. Michael Ohadi, Group Leader for Heat/Mass Transfer Applications, Center for Environmental Energy Engineering, University of Maryland.

KEY WORDS: heat transfer, heat exchangers, electrohydrodynamics

N99-036 TITLE: Non-GPS Navigation Accuracy Improvement for Land and Water

SCIENCE/TECHNOLOGY AREA: Ground and Sea Vehicles

OBJECTIVE: To devise a system to determine position in land and water navigation with an accuracy of better than 1% of distance traveled without using GPS or radar. Low weight, size and cost are also an objective.

DESCRIPTION: GPS is the most accurate navigational means available, but it is also vulnerable to jamming and shadowing. Without GPS, Inertial Navigation is the next most accurate stand-alone system. The effectiveness of Inertial Navigation Systems diminishes in water travel due to currents and drifts.

PHASE I: Devise a system to measure position in land and water without GPS or Radar to an accuracy of less than 1% of distance traveled. The system should use a sensor or combination of sensors that would reduce the vulnerability to jamming and the effects of currents and drifts. Demonstrate the feasibility to do this in a device that is small, lightweight, and affordable and calculate the expected accuracy and reliability. Demonstrate a prototype devise under laboratory conditions and document the results.

PHASE II: Build and test a prototype model, present the test results, including the accuracy achieved. State what effort will be required to decrease the size and weight and increase reliability in production. Estimate the unit cost for expected quantities in production.

PHASE III: Package the device into a modular system that could easily be installed on civilian and military vehicles.

COMMERCIAL POTENTIAL: The commercial potential for this system will be in all aspects of marine navigation, commercial, pleasure, and military.

KEY WORDS: navigation; marine; modular; small; light

N99-037 TITLE: MARINE COLLISION AVOIDANCE DEVICE

OBJECTIVE: To devise a system which will detect water subsurface obstacles at depths of 20 feet or less, while operating in a marine environment.

DESCRIPTION: At a speed of 25 nmph, a surface craft needs light weight, physically small size detection device which will provide warning in sufficient time for the driver to react.

PHASE I: Devise a concept to detect water surface and subsurface obstacles at depths of 20 feet or less, while operating in a marine environment with minimal signal emission. Demonstrate the feasibility to do this in a device that is small, lightweight, and affordable and calculate the expected reliability. Determine the range that the device can accurately detect obstacles, and the distance the emissions can be detected by an outside detector. Demonstrate a prototype devise under laboratory conditions and document the results.

PHASE II: Build and test a full scale prototype and present the test results, including the distance and accuracy achieved. State what effort will be required to decrease the size and weight, increase reliability and range in production. Estimate the unit cost for expected quantities in production.

PHASE III: Package the device into a modular system that could easily be installed on civilian and military vehicles.

COMMERCIAL POTENTIAL: The commercial potential for this system will be in aspects of marine navigation; commercial, pleasure, military, and amphibious.

KEY WORDS: navigation, marine, collision avoidance, small, light

N99-038 TITLE: Roll Safety Improvements for Narrow Track Vehicles

SCIENCE/TECHNOLOGY AREA: Surface/Under Surface Vehicles/Ground Vehicles

OBJECTIVE: The objective of this effort is to develop innovative methods and hardware solutions to mitigate roll over tendencies of V-22 Tiltrotor internally transportable light tactical vehicles during high g-force maneuvers.

DESCRIPTION: The MV-22 Tiltrotor aircraft is the Marine Corps medium lift replacement for the CH-46 and will be used to transport lightweight, highly maneuverable four wheel drive vehicles. These vehicles, which typically have high ground clearance

and therefore center of gravity for off road mobility, must have a width less than 68" to facilitate entry into the cargo area. This combination of high c.g. and narrow track width, combined with unpredictable off-road terrain and aggressive driving under combat conditions, can lead to the increased probability of vehicle roll incidents. Recent government testing and safety certification of the Helo Transportable Tactical Vehicle (HTTV) at the Aberdeen Test Center (ATC) has verified this problem. This effort will research and develop a quick response active roll control system using body roll sensors linked to the suspension system to shift the vehicle c.g. as necessary (e.g. sudden lane change maneuver) to avoid vehicle roll over.

PHASE I: Utilizing the government owned HTTV as a baseline vehicle, investigate technologies, devices, and control systems and algorithms necessary to limit the body roll angle to less than 5 degrees during a .6g maneuver. Calculation and prediction of performance improvements should be made. Perform conceptual design studies followed by preliminary hardware designs and the generation of control software strategy. Identify any new components and/or modifications to existing vehicle components necessary to integrate the system to the HTTV. Generate a test plan and procedures to qualify the system on an HTTV at ATC during Phase II.

PHASE II: Perform system and component detailed design and generate control system software code as necessary. Fabricate all necessary new components and modify existing vehicle suspension components. Integrate roll control system onto vehicle. Refine vehicle test plan and perform tests at ATC to certify the performance and safety of the vehicle. Generate final report.

PHASE III: Transition roll control systems to the Marine Corps' Light Strike Vehicle and Internally Transportable-Light Tactical Vehicle programs.

COMMERCIAL POTENTIAL: This system could be used to increase the safety of sport utility vehicles that are prone to roll problems during sudden lane change maneuvers.

REFERENCES: RST-V Home Page: http//www.usmc-awt.brtrc.com/rst-v/rstv.htm

KEY WORDS: Mobility; steering, roll control, active, suspension, stability

N99-039 TITLE: Lightweight Armor Solution

SCIENCE/TECHNOLOGY AREA: Materials / Manufacturing Science

OBJECTIVE: Design an armor solution for application to the AAAV (Advanced Amphibious Assault Vehicle) with a density of less than 17 lb/ft^2.

DESCRIPTION: Weight is critical to the success of the AAAV program. Armor is a major contributor to the overall weight of the vehicle and is a prime candidate for weight reduction initiatives. An armor system of less than 17 lbs/ft^2 may be viable. A lighter weight armor solution for the vehicle could potentially result in as much as a 1000 lbs. savings. The weight savings could also be applied to increasing the combat effectiveness of the system. The contractor must possess a secrete clearance prior to award of this SBIR.

PHASE I: Develop and build solutions for an armor system which is less than 17 lb/ft^2 that meets the AAAV Armor Specification requirements to defeat a 14.5mm threat at 300 meters and a 155mm artillery bursts at 50 ft. The resultant armor design must posses the capability of being readily integrated into the modular armor concept of the vehicle. The vender must demonstrate that the design meets the requirements though laboratory tests or simulations.

PHASE II: Produce prototype armor and support government ballistic testing. Develop a manufacturing scheme to mass-produce the armor, capable of outfitting the AAAV in full-scale production.

PHASE III: Investigate the use of the armor solution on vehicles expected to endure explosive environments. (security vehicles, armored diplomat carriers, etc...)

COMMERCIAL POTENTIAL: Potential in lighter weight armor solutions for security vehicle where weight and armor protection is a concern. Any light armored vehicle expected to be in an explosive environment (fire fighting vehicles, protection of vulnerable equipment on oil rigs, etc...)

REFERENCE: AAAV Armor Specification, classified at the secrete level.

KEY WORDS: Lightweight, Armor, Advance Amphibious Assault Vehicle (AAAV),

N99-040 TITLE: Expedient Foam Technologies for Marine Corps Operations

SCIENCE/TECHNOLOGY AREA: Materials, Processes and Structures

OBJECTIVE: Demonstrate the capability and affordability of rigid polyurethane foams (RPF) as an expedient construction material to improve the operational capability of Marine Corps units conducting expeditionary operations.

DESCRIPTION: This project will develop and test a deployable rigid polyurethane foam dispensing unit to use in field demonstrations of foamed facilities to support Marine Corps expeditionary operations. Demonstrations of field applications of RPF will include, but are not limited to, a gap crossing, barrier material, channeling material, stabilized beach and marsh roadways for tactical and cargo handling equipment. Ongoing research on RPF material properties will be tailored toward Marine Corps expeditionary applications. The demonstrations will show the utility as well as the affordability of RPF as a construction material for Marine Corps expeditionary operations. The project will develop techniques and hardware required to demonstrate the capability to use RPF as a superior material for use in the expeditionary environment. Scientific work performed to date indicates that RPF foam has extraordinary material properties that make it highly suitable for expeditionary applications. To use RPF to solve existing shortfalls in expeditionary logistics operations requires taking the technology to the next level. The ability to use rigid polyurethane foam (RPF) effectively in expeditionary logistics operations applications requires new methods of dispensing large quantities rapidly, formulating the optimum foam for the expeditionary environment, and structural design concepts to take advantage of the foam's properties.

PHASE I: Determine the engineering issues in the foam selection process; select physical properties (density and strength) of RFP required for expeditionary applications; evaluate combining foam with sand or other abundant local material to add mass if needed; determine if foam should be closed cell or if open cell foams work best for the selected applications. Conduct small scale demonstration for dispensing foam in an expeditionary environment with minimal footprint.

PHASE II: The capability to mix and pour large amounts of RPF in a short time is critical. With existing foam mixing techniques, it would take about five hours to mix and pour the volume of foam equivalent to a 90'x21'x5' pad. Critical engineering issues in mixing and moving RPF include: develop the equipment required to mix and move the foam rapidly into forms; investigate mixing the two foam constituents in place to eliminate pumps and piping; develop methods to dissipate the heat generated by the curing foam. State of the art methods may be scalable to achieve desired mixing goals. The other critical issue to resolve is the RPF formulation that will be most effective for both the expeditionary and beach environments. The usefulness of the foam is in the simplicity of formulation and application, as well as its physical properties. The constituents of the foam must be examined to select properties for the expeditionary applications. Develop a large volume RPF dispensing unit and foam constituents suitable for field use by expeditionary forces.

PHASE III: Commercial availability of materials and dispensing systems.

COMMERCIAL POTENTIAL: This type of equipment for placing large amounts of foam could be use in any area that uses significant amounts of RPF. An example would be in installing RPF as a building insulation.

REFERENCES:

1. Sandia Laboratories has been involved in development of RPF technology for several years under an memorandum of understanding between the department of energy and the department of defense (Office of Munitions). Sandia's work is monitored by a steering committee, which has representatives from the Navy, the USMC, the Navy's shore technical community. The US Army is expected to be represented this year. Sandia is funded over the next two years to complete tasks associated with obstacle and mine field breaching. Some of the tasks scheduled for the next two years complement the work of this proposal.
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3. Modern Plastics, Mid October Issue.
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KEY WORDS: Foam; urethane; polyurethane; construction

N99-041 TITLE: Urban Mobility Planning and Awareness Tool

SCIENCE/TECHNOLOGY AREA: Surface/Under Surface Vehicles/Ground Vehicles

OBJECTIVE: To provide Marine Corps strategists the ability to plan for, and operate within, urban environments in support of both

wartime and humanitarian objectives.

DESCRIPTION: It has been anticipated that future military operations will occur in the urban areas of the world's littoral environment. The mobility of troops and equipment through the strict confines and unique barriers of an urban environment presents new challenges to the strategists responsible for planning for operations in this environment. The quick response time required to meet these operations preclude advanced planning, preparations, and installation of mission and geographic specific equipment onto vehicles used for such missions. Vehicle operators need mission planning tools and mobility awareness tools to assist drivers and commanders in conducting operations. This effort will use all available information regarding urban area topology and general characteristics to provide advanced planning, in situ awareness, and near real time reports on obstacles that are likely to be encountered during urban operations. This Driver's Information and Direction Panel (DIDP) will provide navigational and awareness information via maps generated from scanned-in images downloaded to the vehicle DIDP and developed while onboard ship or in transit to the area of operation. The urban terrain data can be used as a planning tool for operators and as a mission awareness report for location and reporting of terrain features (e.g., "streets are generally xx inches narrow", "street types are 20% clay, 10% paved, 60% unimproved", or "80% of the buildings are less than 3 stories tall").

PHASE I: Develop concepts, perform trade-off analysis, and design a Drivers Information and Direction Panel (DIDP) to be used as a common add-on system aboard various USMC vehicles (e.g., AAV, LAV, Tanks, HMMWV, LVS, MTVR, AAAV, SURC, etc.). The DIDP shall include non-magnetic compass, heading indicator, steer-to indicator, way point settings, secondary indicator for relative pointing of turret in relation to hull, differential GPS, low-cost stored map display synced to GPS to show position on terrain, and a back-up system for position and sync to map when GPS signal is lost. The DIDP will be required to operate in both watercraft and land vehicles and must fit within 50 square inches by 3 inches deep for display device and less than 400 cubic inches for storage, processing, and sensor systems. Design goals will be to meet an estimated AURP of less than $1,000 for a production quantity of 10,000 units and extensive use of COTS items (e.g., PCs, mass storage, flat panel displays, scanners, satellite navigation systems for high end automobiles, etc.). Part of the Phase I effort will be to perform trade-off analyses by applying weights and ranking the merits of each functional element to meet the Design-to-Unit Cost goal.

PHASE II: Develop, demonstrate and test a breadboard DIDP unit that has all the features and functional characteristics required to operate in urban environments aboard USMC vehicles.

PHASE III: Based on a successful Phase II effort, develop a prototype model for qualification, test and evaluation, and production purposes, including any required supporting software and documentation, for a Driver Information and Direction Panel unit which will be integrated into an existing USMC vehicle.

COMMERCIAL POTENTIAL: This system could be used by a host of commercial and governmental organizations required to operate within urban environments such as emergency police, medical, and rescue equipment; commercial trucking and distribution companies; civilian traffic reporting and correction; security firms; etc. In addition, this new technology supports the US Department of Transportation's "Intelligent Transportation System" to better regulate and insure safe transit within urban infrastructures.

REFERENCES:
1. Military Operations in Urban Terrain: http://138.156.112.14
2. Actual accounts of operations during Mogadishu, Somalia: http://www3.phillynews.com/packages/somalia
3. Intelligent Transportation System: http://www.its.fhwa.dot.gov

KEY WORDS: Mobility; obstacles; analysis; transportation; urban

N99-042 TITLE: Composite Components for the Advanced Amphibious Assault Vehicle (AAAV)

OBJECTIVE: The AAAV program office is interested in replacing some of the aluminum and steel components in the track and suspension, hull and interior of the vehicle to reduce weight.

DESCRIPTION: Previous attempts to implement composites have run into problems because of the harsh operating environment of the AAAV. The vehicle will operate in sea water, in sand and mud and in dense vegetation. New techniques for laying up composites may allow replacement of components that are currently made of metal while reducing weight and maintaining reliability/durability.

PHASE I: Review the current design of the AAAV to determine where composite technology could be employed to reduce the weight of components by at least 30%. Develop a list of potential candidates and determine what manufacturing processes would be employed to produce the parts. Prepare a report to document the findings including estimates of life cycle cost, reliability and weight savings. Demonstrate the performance of the composites in a laboratory environment and document the results.

PHASE II: Build and test selected parts to prove they meet the requirements of the AAAV. Produce prototypes for

government testing. Evaluate the results of the government testing and make recommendations concerning the suitability of the composites for the AAAV.

PHASE III: Market composite technology developed under this SBIR to other armored vehicle programs. Modify/scale components for commercial applications to include automotive, commercial watercraft and pleasure boats.

COMMERCIAL POTENTIAL: The commercial potential for the resulting technology from this SBIR is unlimited. Composite parts in automobiles, trucks, rail cars, shipping and pleasure craft would increase fuel efficiency, reduce damage caused by corrosion and reduce pollution.

KEY WORDS: composites, lightweight, harsh environment

N99-043 TITLE: Lightweight Overpressure Containment Ammunition Box

SCIENCE/TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: To design lightweight armored ready and stowed ammunition boxes that contain and prevent leakage of propellant gases into a combat vehicle crew space after an overmatching threat. The boxes must provide additional protection from medium level threats and mitigate the effects of higher level threats.

DESCRIPTION: Protection of ammunition within combat vehicles is important to reducing the vulnerability of the system. A ready ammunition box and feed system which contains the overpressure and toxic gases generated due to the effects of overmatching threats is required. A similar concept is needed for stowed ammunition. Both concepts must provide mechanisms for venting the gases to the exterior of the vehicle.

PHASE I: Develop and provide a design for these ammunition boxes which protect, contain and vent exterior to the vehicle overpressure gases generated by ammunition ignition by an overmatching threat. The design must meet the operational requirements of the AAAV Fire Power components. The vendor will be required to demonstrate through mathematical calculations and modeling that the design meets the above requirements. The boxes shall be designed so they can be integrated into the vehicle as modular units.

PHASE II: Produce prototype boxes and support government ballistic testing using potential overmatching threats along typical vehicle shot lines. Develop a manufacturing scheme to mass-produce the armor, capable of outfitting the AAAV in full-scale production.

PHASE III: Investigate potential of design to be implemented in the containment and shipment of volatile materials.

REFERENCE: AAAV ammunition box interface drawings. Non-Disclosure agreement with General Dynamics is required to obtain these drawings.

COMMERCIAL POTENTIAL: The design and design concepts could be used in luggage carrying boxes in airplanes to protect against terrorist attack. These concepts could also be used in shipping volatile materials, such as explosives, from destroying the carrier in case of an accident.

NAVAL AVIATION TEAM

N99-044 TITLE: Oxygen System Trickle Charger

SCIENCE/TECHNOLOGY AREA: Materials; Human-System Interfaces

OBJECTIVE: To develop an aircraft oxygen generator for trickle-charging high-pressure gaseous oxygen supplies.

DESCRIPTION: Many military and commercial aircraft use high-pressure gaseous oxygen cylinders to supply the aircrew with oxygen during emergency operations. These systems require periodic inspection, testing, and servicing. An airframe-mounted oxygen-generating system is needed to replenish the system after testing, preflighting, and routine leakage. The system must be able to generate 2 to 4 ambient liters per minute of 99.9-percent pure oxygen. The operating altitude is sea level to 50,000 feet. The oxygen must then be pressurized to 2500 psig for storage. The system must use electrical power only (i.e., no source of compressed air is available). The system must be intrinsically safe (low operating temperature) with minimal moving parts. The system must also have an immediate startup capability at room temperature.

PHASE I: Focus is on the materials research required to produce the required oxygen. Perform trade studies to assess the state of the art in advanced materials for electrochemical oxygen production. Provide a conceptual design for an aircraft oxygen system trickle charger. The design will include system performance assessment, with consideration for aircraft altitude and temperature. The design should include material selection, geometry, size, weight, failure modes and effects, startup characteristics, and safety. The design should be supported by laboratory data and a working bench-top model to validate the oxygen generation performance at ground level to a pressure of 15 psig. The design should also include a strategy for meeting the 2500-psig requirement.

PHASE II: Develop and demonstrate an oxygen system trickle charger for a multipassenger (Navy, USAF, or commercial) aircraft. Optimize the design, develop special tools or tooling, generate tooling using state-of-the-art CAD/CAM techniques, optimize components, and produce laboratory and prototype flight test hardware. This phase will also include qualification test planning, life-cycle cost estimating, cost estimating for full production, and reliability and maintainability assessment.

PHASE III: Optimize aircraft integration. Produce the oxygen system trickle charger demonstrated in Phase II.

COMMERCIAL POTENTIAL: Commercial airlines and medical facilities use high-pressure gaseous systems and will benefit from this effort. This proposal requires advance development, with direct application to the $10 billion commercial market for oxygen equipment.

REFERENCES:

1) AFGS-87226A, USAF Guide Specification for Oxygen Systems.
2) JSCG-1776-11, Joint Service Guide Specification for Oxygen Systems.

N99-045 TITLE: Cost Estimation Model for Aircraft Weapons Integration

SCIENCE/TECHNOLOGY AREA: Modeling and Simulation

OBJECTIVE: Develop a model for predicting aircraft integration and certification cost.

DESCRIPTION: Historically, aircraft integration and certification are major cost and schedule drivers for new aircraft acquisition programs, as well as system upgrades. It is envisioned that such a model would be utilized for predicting cost and schedule requirements throughout the life cycle of an aircraft program. Another purpose of this cost model would be to evaluate cost benefits of new tools and technology applicable to this technology area. The model must be able to predict the certification and integration cost of weapons on a new tactical aircraft, as well as on new weapons on existing platforms or system upgrades.

PHASE I: Conduct a detailed study of the types of cost models that could be developed to predict aircraft integration and certification cost. The study must indicate what parameters would be tracked and what cost methodologies are being employed.

PHASE II: Based on study results obtained from Phase I, develop and demonstrate a cost model which predicts aircraft integration and certification cost. A method or recommendations must also detail how such a model would be validated.

PHASE III: The availability and demonstration of an accurate model to predict cost and schedule requirements for aircraft integration and certification will have a significant payoff for commercial and military applications. Major aircraft acquisition programs have limited capabilities to determine out-year funding and for the Government to better plan and manage its resources in this area. An added benefit of this model is the identification of the potential payoff of new engineering tools and technologies being inserted into the process to reduce cost and schedule requirements. This will assist in determining the technology.

REFERENCES: MIL-HDBK-1763 and NAVAIR INST 13100.14

N99-046 TITLE: Innovative Methods for Incorporating Lightning Protection in the Applique Technology

SCIENCE/TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: To develop a technology which can be incorporated in the applique to meet the lightning protection requirement for composite structures. The technology shall meet the performance requirements of MIL-STD-464.

DESCRIPTION: For Naval aircraft systems, subsystems and components are typically designed so that there is no loss of life or vehicle from severe lightning attachment with a 200-kiloamps first-return stroke having a peak rise time of 1.4×10^{11} amps/sec to the aircraft. In addition, naval aircraft systems are designed so that there are no personal injuries and/or endangered mission success from a lightning attachment with a 50-kiloamps first return with peak rise time of 3.5×10^{10} amps/sec to the aircraft. The naval

aircraft is designed with the capability of being restored to its original lightning protection after the repair or replacement of systems, subsystems, or components due to wear, tear, corrosion, or damage-8,2,B.Composite structures are being designed with copper mesh on the exterior surface to meet the lightning protection requirements for aircraft design. Currently, there is no approved technology which can depaint without damaging the copper mesh. In addition, repair procedures performed on these composite structures are more difficult and costly. The applique technology is being developed to replace the topcoat on aircraft. Having the lightning protection integrated in the applique will result in less difficult and costly repair procedures for composite structures.

PHASE I: Develop lightning strike materials technology to incorporate into the applique. This technology shall meet the performance requirements of MIL-STD-464 when placed on the composite structure. Conduct preliminary laboratory testing to demonstrate the feasibility of this technology for composite structure lightning protection.

PHASE II: Further develop the technology to meet the objectives of Phase I results. The contractor shall conduct both laboratory testing and field testing. The above testing shall demonstrate that this technology meets all the performance requirements of MIL-STD-464 for composite structures. If necessary, propose an amendment to the existing Government or commercial specification or propose a new Government or commercial specification to cover this new technology.

PHASE III: Produce the applique with the technology demonstrated in the Phase II effort for both the military and commercial market. If further development and/or field testing is required, aircraft program funding will be pursued.

COMMERCIAL POTENTIAL: An applique with lightning protection capability can be used on commercial aircraft. Therefore, this technology is directly transferable.

REFERENCES: MIL-STD-464

N99-047 TITLE: Crew Centered Armament System for High Technology Cockpit

SCIENCE/TECHNOLOGY AREA: Human-System Interfaces

OBJECTIVE: Develop a Crew Centered Armament System capable of performing Air-to-Air and Air-to-Ground missions using onboard and offboard data through a helmet-mounted display to acquire targets and independently target internally and externally carried weapons.

DESCRIPTION: Modern technology has lead to an explosion in available information emanating from varied sources. Applicable technologies are emerging to deal with information collection, information transmission, information processing, and information display. Properly managed this information can yield: (1) higher probability of kill per weapon launch over conventional aircraft methods, (2) increased target kills per aircraft sortie and (3) capability for mission planning/re-planning enroute. The emergence of Asmart weapons has added complexity with the benefit of flexibility to this complicated issue. Weapon suspension & release equipment will need to manage information flow between weapon and aircraft for target acquisition and independent targeting. The operational requirement to be stealthy, as on the JSF, will revolutionize the method of mission execution and proper information management is the key to meeting the objective. It is anticipated that the Heads-up Display will be replaced with a Helmet-mounted Display (HMD). The best use of HMD has been demonstrated to be the air-to-air mission but the need exists to accommodate the air-to-ground mission. Synthesizing onboard and offboard data to a pilot manageable level needs to deal with varying data: accuracies, timing, range, scale and priorities. The desired system is to create a highly effective crew friendly armament system with high-leverage force multiplication, multiple kills per pass, significantly reduced logistics and high-degree of interoperability across a variety of aircraft. Innovative technologies will be applied in helmet-mounted displays, sensor fusion, information management, human factors and weapon suspension & release equipment. Pilot workload and mission effectiveness enhancement will be considered throughout requirements development. The Awindows of opportunity for integration of these technologies in-part or whole into aircraft block upgrades or developments will be identified as part of the initial feasibility study. Cost per kill and total cost of ownership will be critical metrics for the overall system. Novel and innovative low cost design, manufacturing and supportability concepts will be explored. A Life Cycle Cost (LCC) model will be developed to assess design alternatives and system concepts will be developed, prototyped and demonstrated under this effort.

PHASE I: Provide a final design concept to be demonstrated during Phase II. Conduct a feasibility study to identify candidate aircraft based on operational missions through 2025, and based on the cost and feasibility of aircraft integration during this time frame. Given HMD based armament system technology enhancements identify specific mission tactics for each selected aircraft. Develop system safety/performance requirements and evaluate crew centered armament system design concept alternatives for the selected aircraft. Down select to one concept and identify resultant improvements to the Naval aviation tactical mission emanating from the proposed design concept.

PHASE II: Design, fabricate, demonstrate and evaluate the proposed system. Conduct man-in-the-loop studies to assess pilot workload and survey pilot opinions. Conduct system simulations and performance tests to assess compatibility/effectiveness

in Naval operational and mission environments.

PHASE III: Produce four (4) flight suitable ship-sets. Conduct flight trials to validate system effectiveness and measure performance under dynamic conditions.

COMMERCIAL POTENTIAL: This system has high potential in commercial applications. The aircraft prime contractors of the selected aircraft, crew system equipment developers, weapons developers and foreign military all have high potential as customers of the resulting products. The system will also have the potential for non-military applications where data management and control of electro-mechanical systems is required in a demanding industrial environment. A commercialization study will reveal specific applications for technology transfer.

KEY WORDS: Human-Systems Interface; Air Warfare; Command, Control, Communications, and Computers; Precision Attack; Aircraft Systems; Weapons

N99-048 TITLE: Gas Turbine Hot Section Parts Innovative NDI Systems Research

SCIENCE/TECHNOLOGY AREA: Aircraft Propulsion and Power

OBJECTIVE: Investigate innovative NDI systems, equipment and methodologies to reduce cost of ownership for the DOD gas turbine engine user. Investigate Non-Destructive Inspection NDI techniques capable of repetitively, accurately and economically determining thermally-selective conditions & defects. Examples of such defects include, but are not limited to, the qualitative or quantitative heat transfer effectiveness of cooled blades, bonding quality defect visualization, or cooling hole condition status. The aim of the NDI system will to able to assess suitability for initial or continued engine service of turbine hot section parts, such as combustors, turbine (vanes and blades), and exhaust nozzle parts and assemblies, based upon thermally sensitive characteristics and trends and projected performance variations. Method(s) useful in both pre- & post-assembly and in-situ (non-operational) engines to assess component thermal-resistance and predict qualitatively or quantitatively structural capacity for continued service should be investigated.

DESCRIPTION: Gas turbine hot section engine parts may be assessed for life limiting conditions and/or predictive trends during the manufacturing process and on into field usage. The goal of this effort is to assess the feasibility of detecting and trending governing thermal characteristics of hot section components. For example, trending of blade cooling effectiveness variations and/or growth of thermally indicated structural flaws. In cooperation with a major aircraft turbine engine manufacturer, investiaget and assess the feasibility of an NDI system(s) which is affordable, reliable, with situationally adaptable configurations / user interfaces to evaluate life governing thermal characteristics of current and advanced cooled hot section parts using techniques such as, but not limited to, stimulated gradient IR imaging, semi-quantitative automated image analysis and statistical trend analysis.

PHASE I: Identify types of defects and assess the feasibility potential of a standardized prototype inspection system (hardware, software and support equipment) to semi-qualitatively measure life governing characteristics of to-be-determined regions on combustor, turbine and exhaust air-cooled hardware. Investigate the pre- & post-assembly and engine in-situ inspection system interface configurations & potentail hardware specifications. Define user interface requirements for the technician and, Level I to Level III inspectors for selected defect types. Project the potential cost savings to DOD upon using such new capabilities (e.g., minimize unscheduled engine removals (UERs) and shutdowns). Define applicability to new, reworded, and in-service hot section components.

PHASE II: Develop and demonstrate an NDI system (hardware and software) capable of effectively measuring parameters of interest, such as, heat transfer effectiveness, bonding quality, wall thickness. Further demonstrate in-situ engine inspection configuration accessibility upon applying new NDI systems to detect defect features, such as on full blade surface cooling hole condition assessment. Show tracibility of inspection result trends from new to used combustor, turbine and exhaust nozzle parts and other subassemblies. Re-evaluate the potential cost savings to DOD. Look also beyond airplatform applications exclusively. Further rigorously evaluate potential cost savings of utilizing capability at the engine manufacturer and at overhaul facilities. Develop mature designs for eventual transition into engine production processing & DOD fleet operations.

PHASE III: Commercialized inspection systems and introduce into the marketplace.

COMMERCIAL POTENTIAL: Accurate and economical inspection of complicated air-cooled gas turbine hot section parts is as important to the US commercial aircraft market as it is to the DOD. For example, the commercial gas turbine industry would benefit

from the reduction of inspection costs and unscheduled removals as well. Both commercial and military users will also save maintenance costs by not scraping costly hot section parts that are actually flight worthy and acceptable for additional use. As well marginally perfroming parts will be identified earlier in their life and culled out thus avoiding unscheduled costs.

KEY WORDS: Non-destructive, inspection, non-destructive test, gas turbine, air cooled, hot section, NDI, NDT

N99-049 TITLE: Heating System for Curing Composite Repairs on Complex-Shaped Structures

SCIENCE/TECHNOLOGY AREA: Materials

OBJECTIVE: To develop low-cost, easy-to-use heating systems that can cure composite repairs on complex shaped aircraft structures in a Navy field-level environment.

DESCRIPTION: Standard heat blankets have fixed shapes, such as circular or rectangular, and limited conformability. The repairs to be addressed here will involve curing on double-curved shapes, such as a nose cone, around squared 901 corners, and in areas with multiple frames. To meet these requirements, the system will need to be very flexible in shape and size. The system needs to maintain even temperature distribution ("10 1F) across a repair area of 330 square inches and account for heat sinks due to fasteners and frames. Two cure temperature ranges to be addressed are ambient to 400 1F for most epoxies and ambient to 775 1F for high-temperature composites. Ambient field environmental temperatures can range from 40 to 120 1F. System heat-up rates should range from 1 to 9 1F/minute. Temperatures and heating rates need to be adjustable by 1 1F, and dwell times need to be adjustable by 1 minute. The controller should be capable of inputting an unlimited number of temperature rises and soaks for a particular cure. The user interface of the controller and operation of the heating system shall be understandable at an eighth grade reading level. The controller should also be able to incorporate and control additional heat zones for large repairs. The design of this heating system needs to address the safety requirements for applying heat to operational aircraft.

PHASE I: Evaluate and develop prototype designs for a new heat curing system. Perform market search for commercial and military applications that require cures on complex-shaped structures.

PHASE II: Develop, design, and build field-portable prototype heat curing systems based on the information gathered in Phase I. Field-test these prototypes at Navy, DOD, and commercial composite repair facilities. Market this concept prototype in the military and commercial industry.

PHASE III: Design and develop a commercial production line of the new heating system based on learning experiences from Phase II. Field-test this product line at Navy carrier and field repair facilities to meet the needs of current and emerging aircraft programs, such as the V-22 and F/A-18E/F. Field test this product line at other DOD and commercial composite repair facilities. Market this production line in the military and commercial industry.

COMMERCIAL POTENTIAL: Military and commercial composite repair facilities have been troubled with performing repairs on complex-shaped structures. Often, room-temperature curing systems are used, which have poor mechanical properties and require significant downtime for curing. Hot air guns and heat lamps often use the same materials at a faster rate, but use of these devices is limited due to poor temperature control and safety concerns on operational aircraft. The development of a new heating system under this topic will allow the use of structural repair materials requiring elevated temperature cures and significantly reduce downtime for the repair.

KEY WORDS: Composite Repair

N99-050 TITLE: Advanced Methods for Detection of Aircraft Corrosion Under Paint and Appliques

SCIENCE/TECHNOLOGY AREA: Materials

OBJECTIVE: Aircraft corrosion can often be mitigated through repair and repainting if the corrosion is located before significant damage occurs. The sensitivity of corrosion detection under aircraft paint and appliques needs to be at sensitivity levels sufficient for early repair or monitoring alerts. Corrosion onset is often very localized and sparse, and the objective of this topic is to develop highly sensitive methods for early detection of corrosion hidden by aircraft paint and appliques.

DESCRIPTION: Current aircraft corrosion nondestructive evaluation (NDE) methods include guided wave ultrasonics, eddy currents, and many other NDE approaches. Few, if any, of these are sensitive enough to detect the earliest stages of the onset of corrosion. There may be some advantage to be gained by modifying the paint or applique to enhance the sensitivity of corrosion

detection. Synergistic modification of paints and appliques, coupled with a given NDE technique, should enhance corrosion sensitivity. Paint/applique modifications must be compliant with existing military standards for coatings. A measurable improvement of corrosion detection sensitivity must be demonstrated and quantified, and proposals should address how this improvement will be accomplished in Phase I. Techniques for improving current methods through imaging or data processing are not sought B proposed methods should include innovative sensor/coating interactions that can be exploited to improve corrosion detection sensitivity. This technology would apply to airframe skins including both aircraft and missile structures. The sensor should be able to detect up to 10 ppm Cl and between 2 and 5% moisture content.

PHASE I: Demonstrate, at laboratory specimen scale, the ability to enhance NDE sensitivity to corrosion using a combination of modified paint and optimized sensor designs. It is important to demonstrate the sensitivity advantage provided by the approach over alternate methods. Determine the level of operator training required in practice for aircraft inspection. Systems with minimal training and expertise are preferred. System cost is also an important consideration, and an inspection cost model for an aircraft should be developed for use in Phase II.

PHASE II: Develop an NDE product prototype based on the combination of an engineered paint or applique and sensor technology. Demonstrate that the paint/sensor approach satisfies environmental considerations and is capable of detecting the onset of corrosion in aircraft structures. Phase II tests should include large structures, which show the potential for aircraft inspection. Inspection costs should be estimated for an entire aircraft based on the inspection rates achieved in Phase II testing, training requirements, and operational downtime.

PHASE III: Develop transition plans for the manufacture of proven product (an NDE tool for inspection of corrosion under Applique`) through an industrial partner. If possible submit a proposal for Manaufacturing Technology Program for support.

COMMERCIAL POTENTIAL: A primary commercial target is the airlines, with a secondary target in air transport. As commercial aircraft age, the need for cost-effective and rapid corrosion inspection increases.

KEY WORDS: Under Paint Corrosion; Detection Method; Sensors; NDE; Applique; Aircraft System

N99-051 TITLE: Multipurpose Mobility Platform (MP)2

SCIENCE/TECHNOLOGY AREA: Human/Machine Systems Integration

OBJECTIVE: To develop an inexpensive generic, modular, heavy-lift, stable, reconfigurable, ergonomic omnidirectional electrically powered mobility platform for use in support of Navy and Marine Corps sea-based aviation.

DESCRIPTION: One of the most important elements contributing to the effectiveness and efficiency of Navy and Marine Corps sea-based aviation support systems is the movement of aircraft components, munitions, and other aviation support materiel on the flight deck, hangar deck, and throughout other spaces on the ship. On a typical large deck aircraft carrier, this function consumes many thousands of labor hours, ties up hundreds of personnel, and has hundreds of equipment items dedicated for this purpose.

As naval aviation prepares to enter the 21st century at the center of the nation's defense establishment, two important requirements are emerging that are demanding major changes in the way the Navy operates aircraft at sea. The first of these emerging requirements is the need to reduce the cost of conducting sea-based tactical aviation operations. Two effective ways of achieving this are by reducing the number of personnel required to perform aviation support operations and by reducing the proliferation of aviation support equipment. One effective method of reducing personnel is to reduce workload requirements through technology insertion. Support equipment proliferation can be reduced by reducing both the aggregate quantity and the different types of support equipment needed to support air operations. Technology insertion can also have a major impact on support equipment proliferation.

The second emerging requirement is the need to increase the number of combat missions performed by each aircraft in the sea-based airwing over a given period of time. This is called increasing sortie rates. This requirement has emerged because the Navy will be operating fewer, but more capable, aircraft than it has in the past. To maintain the same level of combat effectiveness, there is a need to generate more sorties. In order to support higher sortie rates, the shipboard aircraft support system must also operate at a higher operational tempo. This means that aircraft turnaround times (TAT) and aircraft support cycle times must be reduced. Thus, material must be moved throughout the ship faster and more efficiently.

To facilitate reductions in personnel workload, to reduce the aggregate number and different types of aviation support equipment needed to transport and handle aviation support material, and to help reduce aircraft support cycle times, a multipurpose mobility platform (MP)2 is needed. The (MP)2 shall be an inexpensive, generic, highly maneuverable, electrically powered mobility platform on which various functional modules can be readily removed and replaced. The (MP)2 shall be omnidirectional to maximize mobility through deck clutter and to contribute to reduced personnel workload. The (MP)2 shall be designed using modular components that will allow it to be readily reconfigured for different applications. The basic mobility platform will be the foundation for future multiple shipboard aviation support applications.

PHASE I: Develop concepts and optimize design for: omni-directional mobility designs; suspension system options to reduce vibration and shock and the effects of shipboard operations; electrical power system alternatives (especially for battery-powered alternatives); and other trades as required. Develop a preliminary design. Prepare and forward a Phase I report.

PHASE II: Design and fabricate a working prototype of the (MP)2. This prototype system will undergo testing at a Navy test facility. (A portion of this testing is anticipated to occur aboard ship.)

PHASE III: Perform additional engineering development as a result of the Phase II test results. Manufacture production systems for shipboard applications. This program will transition to the Naval Aviation Systems Team (TEAM) PMA260 program office. The (MP)2 will be backfitted for use on all existing aircraft carriers and for the future carriers (CVN-76 and CVN-77) and the new carrier design CVX.

COMMERCIAL POTENTIAL: The technology that will be incorporated in the (MP)2 will be readily applicable to the airport equipment industry and the warehouse/material-handling equipment industry.

REFERENCES:

1) Multipurpose Mobility Platform (MP)2 System R&D Guidance Document, dated 8 May 1998.

2) Naval Air Warfare Center, Aircraft Division, Product Evaluation and Verification Department Letter Report: Omni-Directional Vehicle (ODV) Operational Field Evaluation, dated 30 November 1993.

3) Paper: New Family of Omnidirectional and Holonomic Wheeled Platforms for Mobile Robots; Francois Pin and Stephen Killough; IEEE Transactions on Robotics and Automation, Vol. 10, No. 4, August 1994.

KEY WORDS: Omnidirectional Wheels; Material Handling; Aviation Support Equipment; Electric Vehicles

N99-052 TITLE: Passive Obstacle Avoidance System

OBJECTIVE: A passive obstacle avoidance system for helicopter (or other airborne platforms) application that can detect 1 cm diameter wires at 600 meters is needed in order to avoid catastrophic accidents.

DESCRIPTION: The system should be low cost and operate in all weather conditions. One potential alternative is a mid-wave infrared (MWIR) or long wave infrared (LWIR) imaging system with 10E field of regard to allow wide field detection. As an option, a eye-safe laser range finder integrated into the detection system allows important range information. The system should include linear feature obstacle recognition and tracking algorithms for near instantaneous alarm triggering. The imaging system will also serve for ground target detection and as an all weather flying aid.

PHASE I: Determine technical feasibility, operating conditions and low cost of alternative technologies / approaches. This effort will consider research and development of appropriate imaging and ladar sensors for optimum wire detection at maximum ranges. Identification algorithms should be investigated to offer novel approaches for high probability of wire detection. The system should consist of imaging system, optionàl laser ranger, obstacle identification algorithms, software, and recording electronics necessary to identify, display and present alarm for a 1 cm wire at 600 meters.

PHASE II: Design, fabricate, integrate, and demonstrate a prototype airborne obstacle avoidance system.

PHASE III: Cost reduction, weight reduction, system hardened production effort.

COMMERCIAL POTENTIAL: As a low-cost system, this developed technology will have wide commercial application for law enforcement and search and rescue helicopter or other vehicle safety of operation.

KEY WORDS: Passive Imaging, Obstacle Avoidance, Helicopter

N99-053 TITLE: Advanced In-Line Fuel Sampling

OBJECTIVE: Develop a method for continuously monitoring the condition of aviation fuel aboard aircraft carriers, detecting the levels of particulates and contaminants in the fuel and giving an alert if those levels exceed prescribed allowances.

DESCRIPTION: The primary mission of the Aviation Fuels System is to provide aircraft-quality fuel to all U.S. and NATO Aircraft, and to support associated shipboard systems and equipment. This mission is accomplished through rigorous fuel sampling procedures using portable onboard test equipment and shore based laboratories to verify results. Presently, requirements as outlined in numerous directives require a dedicated group of specifically trained division personnel to take approximately 400 to 600 samples per day. They will visually examine the samples and periodically transport samples to a dedicated onboard facility for analysis, looking for

traces of sediment and water.

Fuel sampling is required both prior to aircraft operations and periodically throughout the day. There are approximately 92 aircraft refueling hoses that require sampling onboard CV/CVN's. All service tanks and in-use storage tanks require daily stripping prior to flight operations and periodically throughout the day. Each purifier (4 each) requires continuous monitoring and sampling during the purification process, which is about 18 hours a day, per unit. Additionally, all four 2000 GPM service filters require constant monitoring and sampling along with reclamation filtering, routine stripping, internal/external transferring and receiving fuel from along side tankers. A system that continuously and autonomously monitors the condition of the fuel and eliminates the need to conduct manual fuel sampling could reduce manning by an estimated 13 people, saving over $800K annually and nearly $41M over the life of the carrier. This system could all but eliminate costly onboard test equipment and provide data back to the air systems command real-time for determining engine performance specifications and maintenance failures trends. It would also reduce along side time during periods of underway replenishment by eliminating the time needed to perform sampling before fuel can be accepted, sampling procedures required during refueling evolutions, and costly monthly sampling requirements needed to verify accuracy of test equipment.

The proposed system would require sensors inside the pipe at various key points in the fuel system. These sensors must detect the levels of sediment and water in the fuel as it flows through the pipe. These levels would be displayed on control panels currently in use in the aviation fuels division. A warning indicator would trigger if levels exceed prescribed allowances. Current NAVAIR standards for fuel quality specify that water levels in jet fuel cannot exceed 5 parts per million (PPM) and sediment levels cannot exceed 2 mg/l. Sediment is defined as rubber, dirt, rust, sand, metal shavings and any other solid particulate.

PHASE I: Conduct a feasibility study which develops a concept for in-line fuel sampling for Naval aircraft. This system must be able to operate aboard aircraft carriers, but it should be noted that such a system would have application to shore air stations as well.

PHASE II: Develop, test, and operationally demonstrate the concept formulated under the Phase I effort at a land-based facility at the Naval Aviation Maintenance Training Group, NAS Pensacola, or similar facility modeled after the aviation fuels system aboard a carrier.

PHASE III: Produce the system as demonstrated in Phase II. The system would be transitioned to NAVSEA PMS-312 for retrofit to existing CV/CVN's and PMS-378 for integration into the CVX-78 future carrier design.

COMMERCIAL POTENTIAL: The sensors and algorithms developed for ensuring the quality of aviation fuels aboard the aircraft carrier would directly translate to aviation fuels for commercial aviation operating on the ground, and could be adapted for use in other fluid applications as well, including continuous monitoring of drinking water.

KEY WORDS: Advanced Sensors, Fluid Monitoring

N99-054 TITLE: Autonomous Launch Bar Seating Check

OBJECTIVE: To develop a system that will automatically confirm whether the aircraft's launch bar is correctly engaged into the catapult's shuttle.

DESCRIPTION: A recent incident occurred on the USS Eisenhower where an F/A-18 aircraft was lost because the aircraft's launch bar was not properly seated in the catapult's shuttle. This condition resulted in the launch bar popping out of the shuttle during the launch stroke and the aircraft being launched at an end speed that was too low for flight. Luckily, the pilot was able to eject safely and lived. There were at least four similar incidents in the past two years. The job of checking to see if the launch bar is fully engaged in the shuttle falls to the Hookup Petty Officer (sometimes a safety observer is also involved). The hookup P.O. will make a visual check and sometimes kick the launch bar if it looks like it is not completely seated in the slot. This is the most dangerous job on the flight deck. To check the launch bar and shuttle engagement, the hookup P.O. must be positioned forward of and close to the engine inlet of the aircraft while the aircraft is at full, military power. There are numerous documented instances where the hookup P.O. or the safety observer got sucked into the engine inlet. A system that automatically checks to see if the launch bar is correctly seated in the shuttle and gives a positive or negative indication to the catapult officer and pilot prior to launch, could significantly reduce flight deck fatalities and launch-related mishaps.

The following is a synopsis of the launch process. (1) HOOKUP PREP STOP: Aircraft is stopped with the nose gear just aft of the AY (the beginning of the launch bar guide track). The Director tells the Pilot to extend his launch bar, which falls into the launch bar guide track. During this stop, a Cat Crewman will attach the Repeatable Release Holdback Bar (RRHB) to the rear of the nose landing gear. (2) TAXI ONTO CAT: After the RRHB is secure, the Director tells the Pilot to taxi forward. The launch bar and RRHB glide in the guide track. The RRHB engages the hold back buffer hooks and the aircraft pulls them along until the launch bar drops in front of the cat shuttle and the buffer hits its stops. A Cat Crewman remains with the nose gear ensuring proper hook-up. (3) CAT TENSION: Once the launch bar is positioned in front of the shuttle, the Director simultaneously commands the

Pilot to full military power and the shuttle to be tensioned. Tensioning hydraulically moves the shuttle forward with several thousand pounds of force, tightening the launch bar and RRHB system. This is when the Hookup P.O. checks for proper fit and then runs away. (4) FINAL CHECKS & LAUNCH: The pilot then does a full flight control check (Awipeout) by moving the control stick and rudders to their full deflections several times. If all is well, he salutes the Cat Officer, indicating he is ready for launch. After receiving the pilot's salute, the Cat Officer does one final check of the catapult settings, looks for any obstructions or conflicts, ensures he has a thumbs up from all his crewman, and then commands launch.

The following is a discussion of the technical challenges and relevant information. The cat tensioning step takes between 6 and 10 seconds, so any autonomous system that checks for proper fit must give an indication in no greater than 10 seconds. The launch bar is attached to the aircraft's nose landing gear. At the end of the launch bar is a T-head that is essentially cylindrical in shape, with a diameter of about 2 inches and a length of about 5 inches (the launch bar's width is about 2 inches). As the aircraft taxies forward, the T-head rides along the top of the spreader assembly, which is essentially two side plates a little less than 5 inches apart and attached to the shuttle. The T-head rests just in front of the spreader where the U-shaped slot (the Athroat) is located. (There is an equivalent slot on both side plates.) Once the catapult is tensioned, the spreader jerks forward to Agrab the T-head. For the T-head to be seated properly in the throat, the entire throat must make physical contact with the T-head. Both parts are unpainted steel. Any equipment or sensor that sits on or near the spreader must be able to withstand considerably high temperatures and mass flows from the exhaust of the launching aircraft. Any equipment or sensor that is physically attached to the spreader assembly would also experience a very significant force toward the spreader during the launch stroke and away from the spreader during catapult deceleration (catapult piston striking the water brake). If a sensor sits on the spreader itself, it is suggested that it be wireless, since the shuttle acceleration would quickly destroy any electrical cables that are connected to it. Also keep in mind that operations are conducted in all ranges of ambient light (day, dusk, night), in all weather, in the existence of considerable radio frequency (RF) and electromagnetic (EM) interference, and in the environment of a pitching and rolling ship. System accuracy should be given special focus, since the system must ultimately outperform the human observers. Because aircraft flyaway weight is always a concern, and it is more difficult to affect changes to the aircraft than it is to affect changes to the catapult or ship, higher consideration will be given to approaches that can accomplish the stated goals without need to modify the aircraft or the launch bar. Modifications to the aircraft are allowed, but discouraged.

PHASE I: Conduct a study which develops a concept for autonomously checking the launch bar seating and assesses the feasibility of that concept.

PHASE II: Develop, test and operationally demonstrate the concept formulated under the Phase I effort. The testbed may be a land-based facility (such as the test catapults at Lakehurst or Patuxent River) or shipboard, depending on the complexity of the concept and its integration into the ship.

PHASE III: Produce the system as demonstrated in Phase II. The system would be transitioned to NAVSEA PMS-312 for retrofit to existing CV/CVN's, if applicable, and PMS-378 for integration into the CVX-78 future carrier design.

COMMERCIAL POTENTIAL: This technology could have numerous applications in the commercial sector, including railroads (checking to see if railroad cars are hooked to each other) and trucking (checking to see if the trailer is mated to the cab). Any application where physical contact must be monitored could benefit from the technologies developed under this topic.

REFERENCES:
Available via Defense Technical Information Center (DTIC) support of Small Business Innovation Research Program:
NAEC Drawing No. 614847, Spreader
NAEC Drawing No. 510624, Spreader Assembly
NAEC Drawing No. 607770, Launch Bar

KEY WORDS: Sensors, Sensor Monitoring, Aircraft Launch

N99-055 TITLE: Aircraft Wireless Intercommunications System (WICS)

OBJECTIVE: Develop an in-flight wireless communications system that can be fully integrated with current helmet system and is not subject to interception by electronic warfare threats.

DESCRIPTION: The current Intercommunications System (ICS) for the enlisted aircrew requires a lengthy cord to allow the aircrew to maintain communication with the pilots. The ICS cord is cumbersome and requires the aircrew's constant attention to avoid entanglement while performing their duties in and about the aircraft. An improved ICS capability is required to allow the aircrew unimpeded movement throughout the cabin and to a limited distance outside the aircraft. The WICS will provide greater mobility, improve work efficiency and enhance safety by eliminating the constant trip hazard and distraction associated with the current long communications cord used in the aircrew ICS. The proposed system must be compatible with current headgear or require minimal

modification. The proposed system must not be subject to interception by electronic warfare threats. The proposed system's power supply must provide power for missions of 12 hours in length and must be compatible with aircraft power. Proposed system must be fully compatible with any active / passive noise reduction systems currently in development and must not cause any electronic interference with aircraft. It is desirable that the final system use encryption and communication technology similar to those used in new, non infra-red, Ato-be-fielded survival radio systems.

PASE I: Demonstrate the ability to provide a small, lightweight, multi-user, functional wireless system with work toward elimination of outside electronic threat. A breadboard demonstration unit is desirable

PHASE II: Build and test a working WICS system described above and eliminate product risks before a Phase III program.

PHASE III: Perform an EMD program on the WICS to prove out a system that is fully compatible with current life support system.

COMMERCIAL POTENTIAL: The technology can be used in any high noise environment where portable (non-hardwired) communications is essential.

KEY WORDS: communications; wireless; ICS; helmet

N99-056 TITLE: Inertial Sensor Technology

SCIENCE/TECHNOLOGY AREA: Modeling and Simulation

OBJECTIVE: To extend the performance capabilities of miniaturized inertial sensors for use in critical Navy applications, such as head-tracked weapon targeting systems; greatly improved helmet-mounted displayed (HMD) performance in Naval Aviation simulators and mission rehearsal/planning systems; and inexpensive, accurate instrumentation/test data collection equipment for flight testing and telemetry.

DESCRIPTION: Inertial sensors are essential components of Inertial Navigation Systems (INSs) used in guidance instruments on aircraft, ships, and weapon systems. Miniaturization of the basic INS components (angular rate gyroscopes and linear accelerators) has led to new uses of inertial sensors in automobiles (air bag release sensors). Further size and weight reductions resulting from micromachining technology now permit their use as inexpensive, high-fidelity sensors for human body and object tracking. Inherent properties of inertial sensors offer the potential for high resolution, low latency, unlimited range/working volume, and immunity from noise, electromagnetic interference (EMI), and line-of-sight obstructions. One or more of these problems plague all other tracking technologies. Inertial sensors measure angular rates and linear accelerations directly; therefore, they also greatly improve motion prediction capability.

In order to achieve the full potential of the technology, advanced sensor fusion based on Complementary, Extended, or other new Kalman filter techniques is required to perform dynamic correction of inertial sensor drift and precise prediction of future object states. Increases in computational power allow formulation and validation of high-order, large-state vector algorithms that can be optimized for a given error tolerance in either position or orientation accuracy.

PHASE I: Analyze existing and expected future inertial sensor performance. Identify any deficiencies in sensor characterization and improvements required. Identify mathematical, numerical, statistical, or other techniques needed to formulate and implement optimal sensor fusion algorithms with the properties described above. Identify one or more existing or new Naval Aviation operational, training, mission planning/rehearsal, or other application to demonstrate improved fidelity, functionality, or reduced costs achieved from the use of advanced inertial sensor technology. Determine the mathematical proofs, tests, and analyses to be performed, and the data to be collected, to fully validate new inertial sensor processing and sensor fusion formulations. Develop an implementation methodology and design concept for the Phase II prototype.

PHASE II: Develop improved inertial sensor characterization methods. Develop advanced processing and sensor fusion algorithms. Provide mathematical proofs of optimality. Code the models in the software. Integrate developed software with the inertial sensor hardware and a computing system. Install a prototype on a Navy Aviation system for evaluation. Test and verify the system's performance and ease of use, and quantify improvement over other tracking solutions in fidelity and cost.

PHASE III: Refine and bundle the developed technology as a product suitable for use by commercial and military developers and system integrators.

COMMERCIAL POTENTIAL: Compact, high-performance instrumentation equipment for flight testing and other data collection applications; cockpit sensors (e.g., for head-tracked targeting using a flight HMD/HUD); industrial/professional augmented reality systems for maintenance, inventory, surgery, simulation, training, and teleoperation systems and human/object motion capture and analysis systems; virtual walkthroughs; side effects/simulator sickness reduction in head-mounted display systems; and human factors/psycho-physical/sensorimotor studies. The developed technology will have broad application and mass-market potential for

consumer and location-based entertainment systems. Applicable to all systems requiring low to moderately priced tracking sensors.

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1) http://www.cs.unc.edu/~tracker
2) http://www.cs.unc.edu/~olano/papers/latency (Kalman Filter Home Page)
3) http://www.cs.unc.edu/~welch/kalmanLinks.html (Predictive Tracking Notes Home Page)
4) http://www.cs.unc.edu/~weberh/local.html

KEY WORDS: Inertial sensors; INS; Head-Tracking; HMDs; Targeting; Mission Planning; Mission Rehearsal; Instrumentation; Kalman Filters; Motion Capture

N99-057 TITLE: Advanced Control Features to Adapt Low-Cost Digital Display Based Projectors to Training Simulation

SCIENCE/TECHNOLOGY AREA: Manpower, Personnel, and Training

OBJECTIVE: To develop a capability that allows advanced adjustments of a digital-based projector to effect lower cost of new immersive display systems, as well as to lower the cost of replacing obsolete light valve projectors.

DESCRIPTION: Current digital-based projectors, such as LCD or micro-mirror, provide high luminance at low cost, making them potentially ideal for training simulation. However, their usefulness is greatly limited due to limited adjustability. This limitation also precludes the use of low-cost graphics boards. For instance, dome displays using multiple projectors require warping of the image to correct for distortion at the trainee's eyepoint and to stretch the images to eliminate gaps and overlap between the projected images. This necessitates the use of high-cost CRT-based projectors. CRT-based projectors are inherently dim and require expensive replacement of the CRTs as they degrade. As a result, system cost increases due to special hand-worked high-gain screens, and luminance values are less than desired. Light valve-based projectors provide more light, but are very high cost. Current digital-based projectors have some controls, such as optical keystone correction and digital resizing and reformatting. The digital manipulation of the video image could be increased to include useful functions, including the following: 1) regionally controlled image warping to allow distortion correction and edge matching; 2) regionally controlled brightness to allow uniform brightness and edge matching; 3) user-controlled gamma function; 4) user-controlled pixel-based gain to allow for compensation of screen blemishes; and 5) adjustable edge boundary brightness rolloff to allow blending of overlapped projector images.

PHASE I: Identify which adjustments will be user-controlled. Identify algorithms required to perform the desired types of adjustments. Identify hardware required to perform necessary functions, including block diagrams of required algorithms and system architecture. Identify required performance of key system components, such as memory, bandwidth, and digital processing, which would be anticipated for the Phase II manufacturing effort in years 2000 and 2001. The system should anticipate performance commensurate with digital-based projectors of 2000 and 2001. If the proposed solution is a separate box or board from the projector, identify all related compatibility issues. If the proposed solution is a box or board separate from a projector, identify any other functional advantages which could be applied to driving a helmet-mounted display (i.e., distortion correction, image lag compensation, etc.).

PHASE II: Develop a multichannel prototype system based on Phase I findings. Demonstrate the system's functional capabilities.

PHASE III: Develop a commercial product based on Phase II.

COMMERCIAL POTENTIAL: Real-time, high-performance simulation, such as flight trainers. The ability to create high-quality, low-cost seamless video walls has wide commercial applications, including replacement of movie theatre projectors. Advanced features for digital display-based projectors would require low hardware costs by 2001, thereby becoming widespread. If an external converter board or box is developed instead of a circuit change within the projector, then the HMD industry will benefit with reasonable cost methods of distortion correction and reduction in image lag. (Both are important for reducing simulator sickness.) HMD could also be updated at a low refresh rate, thereby greatly improving the performance of the image generator.

REFERENCES: Stanney, K.M. and Salvendy, G., et al, "After Effects and Sense of Presence in Virtual Environments: Development of an R&D Agenda," International Journal of Human-Computer Interaction, 10(2), 1998, pp. 135-187.

KEY WORDS: Display; Simulation; Imaging; Visual

N99-058 TITLE: Master Training Plan (MTP) Generator for Fleet Replacement Squadrons (FRSs)

SCIENCE/TECHNOLOGY AREA: Software

OBJECTIVE: To improve quality and accuracy of MTPs for FRSs. In addition, reduce the time and effort required to build them so that they can be used more effectively in the planning and allocation of resources for, as well as the conduct of, flight training.

DESCRIPTION: Each FRS is required to build an MTP for each course to accurately map the calendar time needed for completion of the course, or any segment of the course. While it is relatively simple to map the Master Course Schedule (MCS) onto a Master Training Plan for a lock-step course, it is no simple task for the highly individualized courses typical of an FRS. Complex and very dynamic scheduling of events is required at the FRSs in order to accommodate the uncertainties of weather, resource availability, and individual differences in the highly individualized courses. At the same time, these schedules must operate within the constraints of expensive and, consequently, limited resources (e.g., aircraft and flight simulators). Developing and maintaining an accurate MTP is currently an arduous, labor-intensive task. (At one FRS, it takes three people three months to develop its MTP annually and an additional full-time person to maintain it.) However, an accurate MTP is vital to the effective planning and operation of training at an FRS and to the maintenance of Fleet readiness. For planning purposes, the MTP provides a predictor of how long it will take a new student to complete the required curriculum. It also indicates when those already enrolled in training may be expected to complete that training. In addition, it is used as a yardstick against which students can be measured to ensure that training is progressing at an appropriate rate. It is also important to assess the impact of changes to the curriculum, resource availability, or student loading upon the MTP so that changes in course completion times may be anticipated and the cost/benefit of proposed changes accurately evaluated. This research will result in the development of a set of software tools to use the available course curriculum, training resources, and enrollment data, together with historical stochastic data, to accurately build and modify MTPs for the FRSs.

PHASE I: Analyze the detailed generic data requirements for building MTPs for FRSs. Identify the source for each data type and how its acquisition, tracking, and maintenance can best be automated. Analyze the mathematical, numerical, statistical, heuristic, or other relationships that exist between these data and the MTP for an FRS, and determine those most appropriate for application to automating the building of the MTP. Identify the best algorithmic or other automated approach methods for applying the identified relationships to the source data so as to develop the elements of the MTP. Determine the analyses and validation tests needed to ascertain the accuracy of a tool for building MTPs for FRSs. Develop an implementation methodology and design concept for a Phase II prototype tool for building MTPs for FRSs.

PHASE II: Develop a prototype set of generic automated software tools for building the MTPs for FRSs. Install a prototype set of generic software tools at a Navy FRS, and provide implementation and technical support for an on-site beta test evaluation of the software at that FRS. Develop an automated test procedure for validating and refining the MTP for an FRS and use this for testing the accuracy of the MTPs generated by both conventional and automated means at the beta test site FRS.

PHASE III: Refine the MTP generation and testing technology into a product suitable for use by commercial and military developers and system integrators. Provide the refined software at a variety of advanced, weapons platform-specific, flight training squadrons, and provide implementation, training, and technical support for its use by other services involved in the training of flight personnel. Apply the technology developed for dealing with uncertainty in planning to other highly individualized training applications constrained by limited resources.

COMMERCIAL POTENTIAL: The techniques developed will have application to resource allocation problems involving fixed sets of loosely coupled tasks or events when several of those events are tightly constrained by a dynamic set of variables. Application of these techniques will permit improved analysis of large complex processes that are not currently amenable to conventional analysis and will lead to more effective planning and allocation of resources for these processes. Processes to which these techniques might be applied include battle force management and industrial process control, as well as individualized training.

KEY WORDS: Optimization; Resource Utilization; Planning Resource Allocation

N99-059 TITLE: Multispectral High-Fidelity Radar Scene Generator

SCIENCE/TECHNOLOGY AREA Electronic Warfare

OBJECTIVE: To develop the algorithms and efficient processes for producing high-fidelity, wide area, radar scenes using geo-specific multi-spectral data sets and propogation codes for application in siting and predicting the performance degradation of radars (military/FAA) under adverse environmental conditions.

DESCRIPTION: Radar system performance frequently has to be simulated for specific scenarios in different parts of the world. The scenarios require accurate representation of background scattering (clutter) and propagation effects. Use of standard data bases, such as DTED/DFAD, produce only marginal fidelity and generally have too coarse a resolution to portray radar reflectivity accurately. Moreover, propagation phenomena can substantially change the levels of clutter received by the radar, masking target returns. This effort will develop the tools for high-resolution, physics-based radar scene generation using geo-specific multispectral data from multiple sources and will integrate with high-fidelity Parabolic-Wave Equation (PWE) propagation code. The integrated scene will be coupled to radar sensor models, which will enable true end-to-end radar performance simulation in real-world conditions.

PHASE I: Develop algorithms and efficient processes to produce high-fidelity radar scenes using multispectral data sets, and integrate with the propagation code and radar sensor models. A sample scene shall be produced and the process validated against measured data. The efficient processing design shall be a modular, open architecture to facilitate upgrades, integration, and interoperability with radar sensor models.

PHASE II: Develop, test, and demonstrate that the design architecture that was formulated under the successful Phase I effort is capable of producing deterministic, high-fidelity scenes on a worldwide basis. In addition, demonstrate end-to-end simulation capability with frequency domain sensor models.

PHASE III: Produce the scene generation capability for use in tactical decision aids, mission simulators, and training systems.

COMMERCIAL POTENTIAL: The new tools and methodology for radar scene generation and clutter prediction will enable improved siting of radars, better coverage predictions under adverse environmental conditions, and improved training for commercial airborne weather radars that must contend with clutter backscatter from the terrain and sea.

KEY WORDS: Radar; Algorithms; Processes; Propagation

N99-060 TITLE: Human Sensory Physiological Models for Centrifuge-Based Flight Environment Training (CFET) for Recognition of Disorientation and Recovery from Out-of-Control Flight

SCIENCE/TECHNOLOGY AREA: Modeling and Simulation

OBJECTIVE: To develop a capability to train pilots to recognize disorientation in a dynamic sustained-g environment and recover from out-of-control flight situations.

DESCRIPTION: The following is a partial list of out-of-control flight situations: Flat spin (asymmetrical thrust); Inverted flight; Inverted spin; Backward acceleration; Stalls; Zero airspeed; Incipient spin; Steady-state spin (centerline thrust); Positive Gx/high yaw rate spin; Negative directional stability; Disorientation (G-Stress); Performance degradation under G-Stress;Post G-LOC performance. Recovery from some of these flight situations had been taught in the T-2C aircraft. The T-2C aircraft is leaving the inventory and the replacement, the T-45 aircraft, cannot be used to train in recovery from these out-of-control flight situations. The question is whether CFET can be reconfigured to provide this training. Current CFET technology has been developed with computer control dual axis to provide a basic capacity to allow growth for a variety of recovery training capabilities not yet determined.

PHASE I: Analyze and identify the spatial disorientation and out-of-control flight situations amenable to adaptation as CFET out-of-control flight recovery programs. The criterion for amenability would be the predicted effectiveness of the physiological sensory models for each out-of-control flight situation for adaptation as a CFET flight recovery program.

PHASE II: Based on the results of Phase I, develop the associated human sensory physiological models and performance specifications for design and development of the centrifuge gondolas and flight control algorithms required for CFET flight recovery training. Determine the analyses and validation tests needed to ascertain the accuracy of the human sensory models proposed. Verify, validate, and test the senosory models to ensure CFET application.

PHASE III: Based on the results of Phase II, develop training system functional descriptions that could be used to design, develop, and test the hardware, software, and courseware concept for military CFET flight recovery programs. This activity includes the design and development of performance criterion for testing and acceptance of the individual CFET flight recovery programs.

COMMERCIAL POTENTIAL: Out-of-control flight situations are not unique to military aircraft. The entire aircraft industry would benefit from a curriculum designed for training recovery from out-of-control flight situations.

KEY WORDS: G-LOC; Spin; Spatial-Disorientation; Recovery

N99-061 TITLE: Hostile Urban Entities for Simulators

SCIENCE/TECHNOLOGY AREA: Manpower, Personnel, and Training

OBJECTIVE: To develop the repository of software objects representing urban hostile entities.

DESCRIPTION: Military operations in urban combat environments are influenced by the political nature and climate of the dictating situation. As a result, the rules of engagement governing military personnel actions can be drastically different and potentially counter-productive if applied incorrectly. The limitations imposed on forces for political and strategic reasons often constitute significant obstacles to pure military mission accomplishment. In the reactionary environment of urban combat, awareness of complex hostile behaviors and political influences is crucial to the successful time critical application of the governing rules of engagement. Consequently, simulation based training to successfully execute missions in urban combat environments becomes a critical component of the current naval training efforts. New simulators are planned to be developed to address these new training requirements. With each new simulator, there is a need for maintaining its computer controlled urban oriented entities with which a trainee can interact. The entities can represent individuals, equipment, weapons, structures, causal effects, postures, actions, and behaviors of hostile and ally forces.

A common problem with the development of a new class of simulators is the effective sharing and reuse of data. Typically, each new simulator tends to set up its own infrastructure to acquire and represent the data necessary to run the simulator. To address the problem, the primary goal of the project is to foster the effective and efficient reuse of urban threat data for simulators. During the project effort, a software model for acquiring, maintaining, and using urban hostile entities will be developed and tested on selected simulators. Entities will be characterized by properties of urban environment, which are comprised of: 1) physical level that describes model of human movements and performance degradation; 2) reactive level that selects immediate actions; and 3) reasoning level that provides situation assessment and planning capability.

PHASE I: Investigate capabilities of current software modeling technologies and develop the urban hostile entities concepts.

PHASE II: Develop and implement beta prototypes of the repository using an object-oriented paradigm. Interface the repository with selected simulators to enhance naval aviation training.

PHASE III: Transition of the Phase II prototypes into an integrated repository system. Field-test system and implement revisions.

COMMERCIAL POTENTIAL: Software products resulting from this project can be used by various paramilitary and nonmilitary services with needs for training to operate in urban environments.

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KEY WORDS: Rules of Engagement; Urban Combat Environments; Reuse of Urban Threat Data for Simulators

N99-062 TITLE: Visualization of Weapons Effects for Training and Test and Evaluation

SCIENCE/TECHNOLOGY AREA: Human-System Interfaces

OBJECTIVE: To develop a low-cost system enabling visualization of weapons effects for training and test and evaluation activities.

DESCRIPTION: There is a need within the Navy and other services to develop tools with which to model, present, and visualize weapons effects. The ability to navigate around, in, and through simulated target combat systems would afford operators and design engineers a unique and powerful training and analysis tool. Coupled with physics-based models, visualization in this manner would provide the user with accurate, perceptible displays of information not readily understood in raw data format.

In distributed training and simulation, battlefield casualty predictions are often based upon a probability of weapon hit and kill, assigned based upon various forms of empirical data or heuristics. Using visualization, this raw data could be converted to

provide meaningful feedback to planners and warfighter personnel for better understanding of system effectiveness concerning tactics and weaponry.

The Navy desires to develop an ability for a person to observe, from any aspect angle, the effects of a weapon impact on a ship, aircraft, or land-based target. The visualization can be outside or within the target as desired. In this manner, a person can observe the penetration of the weapon, fragmentation, stress, and heat distribution and be able to assess the damage to the equipment and personnel. This visualization can enhance training and greatly influence behavior.

PHASE I: Conduct relevant literature and technology surveys, to include interface with Navy and other service weapons survivability laboratories and vulnerability/lethality activities. Develop concept papers, detailed plans, and functional requirements for a visualization system, enabling better understanding of weapons effects for use in training and analysis.

PHASE II: Develop a fully functional prototype, and provide demonstration scenarios applicable to training based upon available, validated mathematical models. Determine applicability to high-level architecture.

PHASE III: Develop a fieldable device and process to integrate this new technology into training programs and engineering processes.

COMMERCIAL POTENTIAL: This low-cost visualization system would have great value to the military for all warfare systems where weapon effects are a consideration and for trainers, designers, and warfighters. The potential market for this system in the commercial market would be in safety engineering activities in areas such as automotive, ship, or aeronautical structure design. Related areas could include accident investigation, driver training, and post-crash analysis.

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11) Butler, Geoffrey S., Sensenderfer, Wil, Mehler, Steve, and Squeo, Joe, ADA306022, AWeapons Effects and Performance Data Archival Program, Horizons Technology Incorporated, San Diego, California, 1 March 1996.

KEY WORDS: Data Visualization; Training; Engineering Tool; Finite Element Analysis; Battlefield Visualization; High-Level Architecture; Crash Analysis; Accident Investigation

N99-063 TITLE: Multiplatform, Integrated Virtual Urban Warfare Simulation

SCIENCE/TECHNOLOGY AREA: Software/Computing Technology and Modeling and Simulation

OBJECTIVE: To develop and demonstrate multiplatform motion-based simulated environments.

DESCRIPTION: Demonstrate the feasibility and applicability of integrating multiple simulated vehicle platforms into single simulator platforms as either a test bed for virtual warfare simulation or for training. Motion-based simulation platforms have traditionally been limited to simulating a single vehicle environment at a time. This SBIR topic would be to investigate and demonstrate the feasibility of simulating multiple vehicle environments simultaneously, with independent crew control of each vehicle. Multiple vehicle environments include a number of the same vehicle type operating together or in different areas of the urban battlefield and one or more of each of a number of different vehicle types operating together or in different areas of the urban battlefield. The latter, as an example, may include simultaneous simulation of one or more helicopter types and one or more ground vehicle types, all independently controlled and each with full motion; high-fidelity visuals; realistic crew-station mockups with instruments and controls; and high-fidelity audio (both communications and vehicle and environment sounds).

PHASE I: This phase would be to investigate the feasibility of such a simulation, design a platform to demonstrate this simulation, and develop a test program to validate the demonstration.

PHASE II: This phase would provide a scaleable software prototype and validation of the Phase I-developed techniques for simultaneous control of multiplatform motion-based simulations.

PHASE III: During Phase III, the prototype will be fully scaleable to support the commercialization of the product.

COMMERCIAL POTENTIAL: The technology for simultaneous control of multiplatform motion-based simulations will result in commercial products that can be utilized across various motion-based simulations, with the entertainment industry being primarily targeted.

REFERENCES:
1) "Department of Defense Modeling and Simulation (M&S) Master Plan,"
http://www.dmso.mil/docslib/mspolicy/msmp/1095msmp.
2) Marine Corps Master Plan.

KEY WORDS: Multiple Simulated Vehicle Platforms; Virtual Warfare Simulations; Urban Battlefield; Realistic Crew-Station Mockups

N99-064 TITLE: Advanced Concepts in Terrain Modeling and Rendering

SCIENCE/TECHNOLOGY AREA: Modeling and Simulation

OBJECTIVE: To develop a modeling technique and rendering algorithm for terrain that alleviates known problems associated with the traditional approaches of terrain generation for a visual data base.

DESCRIPTION: Develop a terrain level of detail control criteria based on subtense in screenspace as opposed to distance. In this method, the highest level of detail could be ported right from the source data, and, in real time, vertices and edges could be collapsed, depending on whether the screenspace subtense of a terrain polygon is below a user-specified value.

Also, develop an algorithm for marking certain terrain vertices as noncollapsable to alleviate problems with terrain and feature correlation in a visual data base. This intelligent processing could occur during the data base generation (i.e., when the feature data is draped onto the terrain) or during real time (i.e., when a relocatable tactical player is placed on the terrain).

PHASE I: Provide a feasibility study for the development of modeling techniques for better correlation of features and terrain, as well as better terrain rendering techniques that incorporate more than just distance as criteria for a terrain level of detail switching. These techniques would have to be compatible with standard modeling packages, image generators, and graphics accelerators.

PHASE II: Develop, test, and operationally demonstrate the modeling and rendering techniques formulated under the Phase I SBIR effort.

PHASE III: Produce the modeling and rendering methods demonstrated in the Phase II effort.

COMMERCIAL POTENTIAL: The new methodology would benefit the commercial simulator industry, video games industry, and entertainment industry.

REFERENCES:
1) MIL-STD-188/-182
2) MIL-STD-188/-183

KEY WORDS: Modeling; Visual Data Bases; Terrain

N99-065 TITLE: MIP Insertion for Geo-Specific Imagery

SCIENCE/TECHNOLOGY AREA: Modeling and Simulation

OBJECTIVE: To dramatically improve the appearance of textured terrain in a visual data base when viewed from distances closer than the distance at which the photograph was taken.

DESCRIPTION: The insertion of a higher-resolution, geo-typical texture pattern in the top of the "MIP pyramid" would enable the user to receive valuable cues at lower altitudes. The placement of geo-typical imagery could be governed by the sampling of real features in such NIMA products as Digital Feature Analysis Data (DFAD) or Vector Smart Map (VMAP). Also, with the inserted MIP, levels could be used to add a color bias to the satellite imagery, thus alleviating the monochrome look. Furthermore, if the sampled geotypical textures are stored in resident memory, high-resolution geospecific imagery could be obtained with reasonable texture bandwidth.

(*The term "MIP map" refers to the most popular texture level of detail control algorithm. The acronym is short for the Latin phrase "Multum in parvo" (many things in one place).)

PHASE I: Provide a feasibility study for the insertion of high-resolution geotypical imagery into the geospecific MIP pyramid. Issues to be investigated would include the off-line processing and real-time processing.

PHASE II: Develop, test, and operationally demonstrate the MIP insertion methods formulated under the Phase I SBIR effort.

PHASE III: Produce the MIP insertion methods demonstrated in the Phase II effort. This will be the included as a data base development tool.

COMMERCIAL POTENTIAL: New methodology can be used for the entertainment and video games industry.

REFERENCES:
1) MIL-STD-188/182
2) MIL-STD-188/183

KEY WORDS: Visual Data Bases; Geospecific Imagery; MIP Maps

N99-066 TITLE: Practical Polarization Metrology for the Fiber-Optic Gyroscope (FOG)

SCIENCE/TECHNOLOGY AREA: Sensors

OBJECTIVE: To develop a United States vendor of a FOG polarization metrology device that can be used both by developers and manufacturers of FOG instruments.

DESCRIPTION: The Navy is developing a highly accurate, low-cost FOG device as part of the Precision Strike Navigator (PSN) program currently funded by ONR. The PSN is scheduled to transition to production development in FY00. To develop the optical components needed for the PSN, a polarization metrology device, known as a White Light Interferometer (WLI), is needed. The WLI is usually a research-grade, in-house-developed device. The PSN program has access to research-grade, in-house-built WLIs. A French company currently markets a WLI; however, it is not designed to accommodate the dynamics of preproduction technology development. An instrument is required that: 1) can perform the rapid and continuous scanning needed for real-time troubleshooting; 2) has at least 80dB of dynamic range to characterize low-level coherence effects; 3) is not susceptible to small amplitude fluctuations of the input signal; 4) can scan at least 100 mm with submicron resolution; and 5) has a Fourier Transform capability to display the wavelength spectrum.

PHASE I: Develop a breadboard device and deliver it to the Government for evaluation. This device will be constructed on a suitable optical table having easily available input/output optical couplers for testing a variety of FOG devices. It should have a PC Windows-based software/computer for extensive and flexible control and access of instrument components, as well as numerical routines that are used for extracting the data.

PHASE II: Develop a preproduction device and deliver it to the Government for evaluation. This instrument will be in a standalone mainframe package with a user-friendly control panel and PC-based software/computer with comprehensive operating instructions.

PHASE III: License to manufacturer or set up for commercial manufacturing.

COMMERCIAL POTENTIAL: This device would offer a novel metrology solution to all FOG producers around the world. This instrument provides a practical polarization metrology capability that can test not only FOG devices, but many other integrated electo-optical polarization-sensitive components.

REFERENCES:
1) Patent 5,422,713, 6 June 1995, Birefringent Waveguide Rotational Alignment Method Using White Light Interferometry.
2) Kasumasa Takada, Kasunori Chida, and Juichi Noda, Appl. Opt. Vol. 26, No. 15, pp. 2979-2987.

KEY WORDS: Polarization; Metrology; Fiber-Optic Gyroscope

N99-067 TITLE: Offboard Processing for Air-Deployed Acoustic ASW Sensors

SCIENCE/TECHNOLOGY AREA: Sensors

OBJECTIVE: To use autonomous in-sensor processing and decision-making techniques to enhance performance of future airborne ASW systems.

DESCRIPTION: Future airborne ASW systems will increasingly rely on acoustic-receiving buoys with large numbers of hydrophones and, consequently, large numbers of beams. With buoy-to-aircraft data link limitations, as well as aircraft processing limitations, data that could contain the weak target information may never reach the operator. This SBIR will address how offboard, autonomous processing can be used to provide a force-multiplying effect for the air ASW mission, primarily through active search, but supplemented by passive and nontraditional methods.

PHASE I: Define innovative system-level concepts that maximize the performance of autonomous sensors. Define processing and classification techniques that exploit the full band of signals available in each beam, but fit within the cost/power consumption limitations of a battery-powered processor embedded in a self contained, offboard sensor.

PHASE II: Develop a working prototype of the techniques defined under the Phase I effort. The prototype system will be capable of field operation and will be used to analyze and demonstrate the system and processing concepts using real data furnished by the Government.

PHASE III: Implement the systems concepts and processing techniques in a configuration and package that can be left behind at-sea to process data and transmit results back to a monitor platform.

COMMERCIAL POTENTIAL: The concepts and processing techniques developed under this task can be applied to any kind of commercial systems, sonar or otherwise, where remote site data gathering is required and where the available data link bandwidth cannot support the volume of data collected (e.g., monitoring or surveillance systems where "smart" processing must sort through volumes of data to send an "alert" message with amplifying information over a cellular telephone line).

KEY WORDS: Antisubmarine Warfare; ASW Signal Processing; Offboard Sensors; Autonomous Processing; In-Buoy Processing, Detection, and Classification

N99-068 TITLE: Integration of Mode S into Identification Friend or Foe (IFF) Systems

OBJECTIVE: Determine if integration of Mode S interrogation capabilities is feasible onboard moving platforms, specifically surface combatants and airborne platforms. Incorporate Mode S interrogation capabilities into existing IFF systems. Optimize the use of available Mode S information for improved combat identification. Provide valuable Mode S information to combat systems and data links for distribution throughout a given theater.

DESCRIPTION: IFF systems are used for air traffic control (ATC) purposes, and critical for positive, secure, friend identification. It is essential for these systems to properly identify targets and provide combat/weapons systems with accurate identification for target tracking and friendly target discrimination. Due to deficiencies in Air Traffic Control Radar Beacon System, Mode S was developed and implemented by civil authorities. Although many commercial land based sites have Mode S interrogation capabilities, implementation onboard mobile military platforms is difficult due to lack of physical space, antenna type and size, and the inherent instability of moving platforms. Use of Mode S information is valuable for situational awareness and identification of noncombatants. Most commercial aircraft in the United States and Europe are being fitted with the Mode S transponders. Due to the complexity of Mode S, innovative research needs to be performed to:

1. Determine if Mode S interrogation capability can be implemented on moving and space confined platforms (surface

ships / aircraft).

2. Determine if existing IFF interrogator systems can be modified to gather Mode S data.

3. Determine if these modified systems can provide combat systems and data links with valuable information for dissemination across the entire battle space.

4. Modify existing IFF systems and integrate Mode S interrogation capabilities into the combat/weapons systems.

PHASE I: Perform a comprehensive study of Mode S, identifying the feasibility of implementation onboard moving, space confined platforms and the tactical benefits to the military. Develop various schemes for acquiring Mode S equipped aircraft, Propose an architecture for adding a Mode S interrogation capability to shipboard IFF systems to include operational issues such as use of Mode S datalink, displaying Mode S data, managing a 24-bit aircraft address database, and adding Mode S data into existing tactical datalinks. Report on the utility of, and propose a design for, implementing a passive Mode S capability using the proposed Extended Squitter. Create an innovative, cost-effective design for the implementation of Mode S interrogation capabilities.

PHASE II: Refine the design for integration to shipboard IFF systems. Build and demonstrate a prototype system. Address relevant issues associated with performance, production, and manufacturing.

PHASE III: Transition the prototype system into a Navy and/or other DoD / commercial production program.

COMMERCIAL POTENTIAL: The results of this innovative research can be used by all DoD agencies for enhanced situational awareness. Commercially, this system may be used by international civilian authorities for air traffic management.

REFERENCES:

1. Stevens, Michael C., ASecondary Surveillance Radar, Artech House, Inc., 1988

2. International Standards and Recommended Practices, Aeronautical Telecommunications ANNEX 10, Amendment 71, March 1996

KEY WORDS: IFF; Mode S; Air Traffic Control; combat identification; situational awareness; noncombatants.

N99-069 TITLE: Aircraft Optical Cable Plant (OCP)

OBJECTIVE: Current aircraft utilize mostly copper wire for interconnecting avionics systems. First generation optical interconnects were patterned after copper cabling and use MIL-STD 5088 wiring and MIL-STD38999 connectors. . The currently utilized fiber optic interconnect hardware represents an extension or duplication of existing aircraft electrical cabling and connector technology to fiber optic media. A new generation of hardware is being developed commercially based on ribbon cables, array connectors, planar couplers and related repair and installation tools. It is therefore desirable to develop an advanced high density interconnect system based on emerging technology concepts so that avionics interconnect systems can accommodate growth as the technology matures. This high density interconnect will represent a revolutionary advance in interconnect systems based on optical fiber's unique performance characteristics. The vision is to attain a Amobile vehicle information distribution system analogous to the Apremises distribution systems provided for commercial buildings where all elements of a fiber optic interconnect are designed for compatibility, interchangeability and affordability.

DESCRIPTION: An optical cable plant is an integrated system which provides and supports the physical medium for optical data and control communication in aerospace vehicles. The intent of this program is to take advantage of recent commercial developments in materials, components and manufacturing methods to develop a rugged fiber optic cable plant optimized for aerospace and shipboard applications which can accommodate a variety of optical fiber waveguide types. These waveguide types include single mode and multimode glass/glass fibers and waveguides, plastic clad silica fibers and waveguides, and all plastic fibers and waveguides. This second generation cable plant should represent a dramatic improvement over first generation. The ribbon cable should be extremely robust eliminating any concerns over cable damage or fiber breakage in an aerospace environment. Teaming with component developers is encouraged.

PHASE I:The contractor shall provide a design for an OCP consisting of cables and harnesses, connectors, splices, break-out boxes, backplane interfaces, fiber optic couplers, and include test and maintenance concepts for these items. All materials and cable construction shall be identified to provide operation over aerospace environments. Manufacturing, installation and repair tools, processes and training programs shall be identified. The ribbon format should provide for both redundant serial data transmission or parallel data transfer by providing a scaleable fiber count. Connectors, 180 should be designed to provide an extremely small footprint, with low mass connector shells and array inserts, and accommodate both single and multimode fibers. Cable-to-cable connectors, rack and panel connectors and card edge connectors with various angles shall be included in the design. Fiber spacing and cladding diameter should be standardized and hermetic coatings utilized to guarantee long term reliability. The cable connector interface shall be optimized to preclude damage during installation and/or maintenance actions as well as ease of termination. All elements of the cable plant should be compatible including splices and couplers with minimum weight, volume and footprint. This optimized cable plant, when coupled with electro-optic transceivers, shall serve as the physical layer of an integrated information

distribution system capable of transferring all information on military and commercial aircraft with dramatic improvements in affordability, reliability, fault tolerance, EMI/EMP immunity and safety. Utilization of this cable plant will improve aircraft performance and fuel economy, providing operational cost effectiveness while reducing new aircraft certification costs.

PHASE II: A flight-worthy prototype OCP will be assembled, tested, and delivered to the Navy for installation in fixed and rotary wing military. The compatibility and interchangeability of all cable plant elements will be demonstrated. In addition, installation and repair tools and methods will be defined and demonstrated. All cable, connector and coupler variants shall be delivered as part of the OCP

PHASE III: The cable plant shall be integrated with selected sub-systems to demonstrate installation procedures, in-flight performance and maintenance actions .

COMMERCIAL POTENTIAL:

The products from this SBIR will be shown to have great commercial potential in general aviation market because of their light-weight, low-cost, and high-speed transmission of data.

REFERENCES: SAE Aerospace Resoure Document DRAFT ARD 5271

KEY WORDS: Optical fiber, ribbon cables, array connectors, optical interconnects, planar couplers, flight control system, avionics,

N99-070 TITLE: Space Time Adaptive Processing (STAP) for an Electronically Scanned Circular Array

OBJECTIVE: Develop space-time adaptive processing algorithms to mitigate the effects on target detection due to electronic countermeasures and ground clutter, for use with the U.S. Navy's UHF Electronically Scanned Array (UESA) Advanced Technology Demonstration (ATD).

DESCRIPTION: The RSTER radar system, located at the Pacific Missile Range Facility on the island of Kauai, is being upgraded to serve as a host radar for the U.S. Navy's UESA ATD. RSTER's existing STAP algorithms support a linear array and must be rewritten to work with a ring array. The new STAP should provide maximum immunity against ground/sea clutter and jamming while working within the constraints imposed by expected 2005 computer performance.

PHASE I: Exploratory research effort to understand and characterize the differences between signal processing for linear and circular (ring) apertures

PHASE II: Selection of optimal STAP taxonomy

PHASE III: Algorithm development and insertion in RSTER

COMMERCIAL POTENTIAL: This same technology could be used to enhance reception for circular arrays incorporated into commercial GPS and communications applications.

REFERENCES:

1. Ward, James. 1994. *Space-Time Adaptive Processing for Airborne Radar.* MIT/LL
2. Zatman, Michael. 1998. *Circular Array STAP,* submitted to IEEE Radar Conference

KEY WORDS: Space-time adaptive processing, radar, circular array

N99-071 TITLE: Compact, Low-Cost, Diode Power Supply for Lasers

SCIENCE/TECHNOLOGY AREA: Sensors

OBJECTIVE: To develop a compact, low-cost, power supply required to drive diode bars for pumping advanced laser materials.

DESCRIPTION: The Navy is investing in LADAR and LIDAR technology for many applications, from terrain LADAR, automatic target recognition (ATR) LADAR, and terminal guidance for missile systems to handheld BC detection LIDAR. For all of these applications, a compact, low-cost laser system is paramount in meeting the application objectives. Other programs are developing the cost-reduction technology to get the cost down on the laser head, but the power supply is currently not being addressed. The power supply, cooling system, and laser head will have to be compatible with missile environments and applications.

PHASE I: Develop a breadboard diode power supply capable of driving lasers used for missile applications. The volume

of the power supply shall be < 8 cubic inches. The power output requirements are for a continuous-wave (CW) operation supply with an output of 50W/diode bar with minimum of 2 bars driven. (This could increase and provisions in the design shall accommodate up to 4 bars.) The power supply should support the complete operation of the laser. This could include the operation of a Q-switch and cooling of the diodes (~20W/bar). The PRF should be in the tens of KHz, with a goal of 20 to 30 KHz. Appropriate cooling, if required, should support a continuous run time of up to two hours at full power. The design should be compatible, with application to missile primary power, either 5 Vdc or 28 Vdc. Voltage will be determined at a later time.

PHASE II: Develop a preproduction prototype diode power supply for delivery to the Government for evaluation. This supply will be packaged to be integrated with a Government-owned laser head to provide a laser system for field/flight testing. Compatibility with specific missile applications will be determined during Phase II.

PHASE III: License to manufacturer or set up for commercial manufacturing.

COMMERCIAL POTENTIAL: This power supply could find applications in laser diode drivers for large area displays, communication systems, and medical applications of lasers.

KEY WORDS: Diode Power Supply; Laser; LIDAR; Compact; Low-Cost

N99-072 TITLE: W-Band Short-Pulse IMPATT Diode Development

SCIENCE/TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop a low-cost, highly-reliable, short-pulse IMPATT diode capable of generating 40-50 W of peak RF output power from a discrete device operating at the W-band (75-110 GHz).

DESCRIPTION: The Navy has requirements for high-power, short-pulse, millimeter-wave IMPact Avalanche Transit Time (IMPATT) diodes. There is a foreign source (French) of high powered IMPATT diodes but a domestic U.S. source is desired. Currently the only IMPATT diodes available in the U.S. do not produce 40-50 Watts. Additionally, since they are no longer in active production, the existing devices have to be specially re-packed and have a suspect yield rate. Finally, the existing low power IMPATT diodes are based on 20 year old technology. More recent experimental[1] and theoretical[2] data indicate that 40-50 Watt diodes at 0.5% duty-cycle are producable. Given the advances of technology over the last twenty years it is expected that a new IMPATT diode can be designed which will be technically compliant, low cost and highly reliable such that overall Total Ownership Costs of Navy weapons systems can be reduced without sacrificing performance. A domestic vendor of such a device is greatly desired.

PHASE I: The Contractor will conduct an investigation of IMPATT diode materials, structures, create models, and run computer simulations which predict RF power output and impedance. The contractor must clearly identify the material growth and processing, packaging, impedance matching, and bias modulator technology to be used for the phase II effort.

PHASE II: Conduct material growth, characterization, packaging, and large signal RF testing to achieve 40-50 Watts peak, 0.5% duty-cycle single packaged device.

PHASE III: Produce environmentally qualified, low cost, high power IMPATT diodes for insertion into the Navy program.

COMMERCIAL POTENTIAL: Atmospheric weather radar, communication systems, proximity sensors, collision avoidance radar systems, police radar and automatic RF identification systems.

REFERENCES:
1) W.Behr and J. F. Luy, AHigh-Power Operation Mode of Pulsed IMPATT Diodes, IEEE Electron Device Letters, vol. 11 no. 5, pp. 206-208, 1990

2) P.A. Rolland, C. Dalle, and M.R. Friscourt, APhysical Understanding and Optimum Design of High Power Millimeter-Wave Pulsed IMPATT Diodes, IEEE Electron Device Letters, vol. 12, no. 5, pp. 221-223, 1990

KEY WORDS: millimeter-wave, radar, power, solid-state, IMPATT

N99-073 TITLE: High Power Solid State Components

OBJECTIVE: Develop solid state components for use with high power Silicon-Carbide based transmit modules

DESCRIPTION: Solid state components capable of handling unusually high power loads are needed for integration into the RSTER

radar system, located in the Hawaiian islands on the island of Kauai. The system is being upgraded to act as host radar for the U.S. Navy's FY00 UHF Electronically Scanned Array ATD and subsequent Theater Air Missile Defense Focus Area demonstrations. As part of the upgrade, a switch network must be developed to support the power production capacity of the new Silicon-Carbide based transmitter architecture. Preliminary system architecture analysis indicates that the switches and phase shifters, as well as other components, may not be able to handle the up to ten kilowatt output.

PHASE I: Exploratory research effort to determine the feasibility of a developing an affordable solid state RF and switching components capable of handling up to 10 Kwatts peak power to support the Navy's UHF-band Electronically-Scanned Array (UESA) antenna development ATD.

PHASE II: Design and prototyping of the high power switches.

PHASE III: Manufacture of the switch and integration into a commutation matrix for the RSTER testbed radar.

COMMERCIAL POTENTIAL: The advent of Silicon Carbide-based transistors capable of generating in excess of two kilowatts of power will make possible cellular communication of unprecedented range and fidelity. High power solid state components will be needed to match the power production capacity of these new transistors.

KEY WORDS: Radar, ESA, Switches, switch network

NAVAL SEA SYSTEMS COMMAND

N99-074 TITLE: Submarine Outboard Electrical Cable Connector Improvements

SCIENCE TECHNOLOGY AREA: Material, Process & Structures

OBJECTIVE: Develop and demonstrate innovative electrical connector assemblies which resolve currently observed failures and deficienceis of Submarine outboard cable systems. Based on the disruptive maintenance and cost burden this item places on the Fleet, the Type Commander has placed this item on his Top Management Attention (TMA) list.

DESCRIPTION: Outboard waterborne cables are failing across many submarine CWS and HM&E systems. Outboard systems affected include Vertical Launch System (VLS), Sonar (all types), Towed Array, Masts and Antennas, Bow Planes, 6' countermeasures, anchor light, Secondary Propulsion Motors and connector pin configurations and sizes including 3 to 85 pins. NAVSEA plans to mangage a technical development and testing program that initially identifies the outboard cable connector problems and then determine common solution to all outboard cable connector problems. Note, lessons learned and resources need to be shared across submarine and other Navy programs.

Submarine outboard cabling systems are exposed to mechanical and physical damage, temperature variations of -20 to 140EF, must have an expected life of 12 years minimum, and be capable of grade A shock resistance. In addition, the various innovative design improvements will be exposed to a seawater and salt-air environment and extreme submergence pressures.

PHASE I: Design a connector assembly capable accomplishing the required performance. Survey the available connector assembly schemes that may be capable of being modified and programmed to accomplish the required performance. A review of observed failures and lessons learned from all affected systems is required. Provide recommendations as to which cable connector system(s) are a basis for further development and prototype, and apply trade-offs based on key attributes. Develop a detailed plan to convert requirements into a prototype system. The survey and plan should include technical, cost and schedule estiamtes and associated risks.

PHASE II: Based on survey results and plan recommendation in Phase I, design, develop or modify, as required, and test specific improvements to various outboard cable system types.

PHASE III: Fully integrate the successfully demonstrated improved cable assembly types. Liaison with the SBIR POC for land-based verification and validation and eventual at-sea testing.

COMMERCIAL POTENTIAL: Application to the design and development of new marine vehicle or structure electrical systems exposed to a liquid or spray environment. In addition, the improved cable assembly features will be highly beneficial to all applications which depend on reliable electrical cable integrity and the proper mating of electrical connectors including Aerospace, Communications, computer applications, etc.

REFERENCES: (available at Defense Technical Information Center)
NAVSEA Molding Manual
Weapons Delivery System Equipment Manual (WDSEM Vol V)
Application Affected System Drawings
Ship Specifications for Deep Diving Submarines

KEY WORDS: Electrical Connector; Cable Assembly; Molding Practices; Outboard Cables; Mating; Training

N99-075 TITLE: Advanced Submarine Coatings

OBJECTIVE: Investigate new approaches to submarine coatings that have less compressibility (reduce ship design impact) while providing equal or better performance in signature reduction when compared to currently used coatings.

DESCRIPTION: The current family of voided urethane materials used for submarine external hull coatings has limited potential for future stealth performance gains without excessively impacting the overall ship design and performance. To meet challenging future stealth goals, new approaches and concepts need to be developed. Examples might include non-homogenous materials or tuned passive resonance materials. Concepts must be compatible with the sea water environment and durable enough for external submarine application. External coatings are used in combination with other signature reduction strategies. More effective coatings will result in less need for other treatments and attendant cost savings.

PHASE I: Develop innovative, stealthy submarine coatings meeting the objective(s) of this Topic. Select a concept and perform preliminary investigations to determine anticipated performance and address feasibility for installation on submarines.

PHASE II: Build samples of the coating concept and conduct testing to validate performance.

PHASE III: Shipyards and Navy laboratories will participate with the small business concept developer to investigate large scale material fabrication, submarine application, material and process specifications, and optimal coating design using the new concept.

COMMERCIAL POTENTIAL: Products developed under this topic have performance aspects in common with coatings used in the transportation industry to meet acoustic, structural, and corrosion needs. In addition to the products themselves, there is a potential to share related analysis and modeling capabilities between industry and government.

KEY WORDS: Coatings; materials; submarine; external; stealth;

N99-076 TITLE: Non-Destructive Testing (NDT) Method for Locating and Plotting Flaws in Elastomer Components

OBJECTIVE: Develop a method to determine the size, orientation, and location of flaws found in elastomer components.

DESCRIPTION: The technology to accumulate and store significant levels of strain energy in an elastomer has been demonstrated by the inflation of large (8' diameter, 10" thick) disks, spheres, etc. The need to accurately locate small flaws (1/8" x 1") introduced during fabrication below the surface of the elastomer part is critical to the safety, operational performance, proof testing, and quality assurance of such parts. This effort would use the innovative implementation of existing and new technology to design and fabricate a suitable sensor system for the above application.

Existing methods used for NDT include low frequency ultrasonics, xerography, tomography, and fluoroscopy. Ultrasonic methods are well suited for measuring the thickness of a rubber part, but have difficulty in conveying the orientation, overall size, and type of the flaw. X-Ray methods such as xerography and fluoroscopy have been used to locate flaws, but their accuracy is susceptible to the orientation of the flaw with respect to the X-Ray beam.

PHASE I: Develop innovative concept design(s) and a breadboard demonstration in sufficient detail to assess performance and cost of a manufactured device.

PHASE II: Fabricate prototype device and conduct in-situ evaluations with actual or elastomer components. Optimize performance and accuracy while maximizing repeatability.

PHASE III: Manufacture production device packages including operating instructions and specifications. Sell devises

to Navy and/or manufacturer of Elastomeric Ejection System components, or other highly strained elastomeric components, for production quality control, product acceptance tests, and in-service quality inspection.

COMMERCIAL POTENTIAL: The use of elastomers and rubber materials in industry and consumer products is ubiquitous. Flaw locating and plotting capabilities will not be limited to highly strained disks and spheres. This technique will enable manufactures to routinely inspect prototypes during product development as well as production and in service hardware.

REFERENCES:

1. Halsey, G.H., Nondestructive Testing, Rubber Age, February, 1968.
2. Dodge, D.D., Principles and Applications of Non-destructive Testing, American Society of Mechanical Engineers, Paper No. 61-WA-323, 1961.

KEYWORDS: Non Destructive Testing; NDT; sensor; elastomer; transducer; rubber

N99-077 TITLE: Open Architecture, Windows/MFC Engineering Geometry System Generator Encapsulating GOBS / DT_NURBS (GeometryObject Server (GOBS) initiative, with its underlying David Taylor Non Uniform Rational Basis Spline)

OBJECTIVE: Create a geometry kernel, utilizing the advanced engineering features of the GOBS/DT_NURBS geometry representations, within a software development environment widely applicable to design and analysis codes for naval ships; provide for an order of magnitude increase in productivity and decrease in cost for development of geometry related software codes.

DESCRIPTION: Past experience with existing CAD (Computer Aided Design) systems and solid modeling kernels has highlighted the need for broad access to open, common representations to support naval ship design and simulation efforts. The Geometry Object Server (GOBS) initiative, with its underlying David Taylor Non Uniform Rational Basis Spline (DTNURBS) representation, is proving effective in provision of a common geometry representation for this purpose. In addition, Windows NT/95/98 based software products have become an accepted part of many activities in NAVSEA, including naval engineering efforts. In the near future, most young engineers will have been trained on Windows based systems, which they have used in school and at home. Although full scale engineering development efforts will generally remain UNIX based, the low cost of PC equipment, combined with the availability of Windows knowledgeable engineers, suggests that provision of a Windows / GOBS / DT_NURBS development environment will enable the Navy to leverage the effectiveness of both technologies in a wide range of smaller scale applications and simulations.

Experience with existing systems has also suggested that no single CAD system or geometry library (e.g., ACIS, Parasolid) will provide cost effective solutions to the problems presented in naval ship design. For example, an expensive, full size CAD package might be used to determine a volume that can be calculated using a very small number of API (application programming interface) calls into the CAD systemís kernel. However, because access at such levels is so complex - a programmer is always required - it is not currently practical to provide the much more compact and simpler programs that should be possible in theory. The goal of this SBIR is to explore the feasibility of a GOBS/DT_NURBS geometry interface generator utilizing MFC (Microsoft Foundation Classes) and augmented Visual C++ Application Wizard technology or some alternate technology. The generator system should enable an engineer to specify the design of their interface into GOBS in high level terms, and the system should generate open, MFC compatible C++ code. The generation of ActiveX control code for incorporation into derived Visual Basic applications should be considered.

PHASE I: Research the current GOBS/DT_NURBS system. Identify, research and design: i) a small but composable set of editing operations defined over GOBS; and, ii) a small but composable set of user interface mechanisms. Using augmented Application Wizard technology or an alternate proposed technology, demonstrate the generation of simple editing interfaces into GOBS as determined by high level specifications.

PHASE II: The design concept developed during Phase I should be scaled up to support generation of useable GOBS interfaces through an alpha version of the generator. This work should include extensions to the editing operations, user interface mechanisms and generator mechanisms. Issues associated with the representation of high level specifications for this purpose should be explored in depth. A problem involving early stage naval ship design should be identified, researched, and used as a test case.

PHASE III: The phase II system will be refined to produce a beta software version, and that version will be used in the creation of a family of GOBS based applications involving early stage naval ship design and analysis.

COMMERCIAL POTENTIAL: By decreasing the time and complexity of generating editing interfaces into GOBS / DT_NURBS, the proposed technology could stimulate the growth of both developers and users of that evolving geometry kernel. As a result, more modern, robust, lower development cost alternates to existing solid modeling core technology should become available.

REFERENCES:

1) DT_NURBS User Manual, Reference Manual, Theory Manual. http://dtnet33-199.dt.navy.mil/DT_NURBS/doc.htm.
2) Microsoft Visual C++ on line documentation.

KEY WORDS: DT_NURBS, GOBS, Naval Ship Design, CAD, Program Generators, Software Development

N99-078 TITLE: Testability and Certification of Complex Software in Total Ship Computer Environments

SCIENCE/TECHNOLOGY AREA: Software

OBJECTIVE: The objective of this topic is to develop technologies to address the testability and certification of complex software-intensive application/systems within a total ship computing environment. The testability and certification must be supported in an environment where software tasks may be dynamically allocated across the computer resources. Of particular concern is the ability to test/certify functionality, real-time response, and availability factors.

DESCRIPTION: Computer system plant, such as the one envisioned for the next generation surface combatant, DD21, will provide support for the breadth of computational needs within the ship. System applications will provide the software, actuators and sensors, while the ship will provide the computational resources. The challenge is to provide sufficient confidence in testing and certification that the application's functionality will be provided with sufficient quality and predictability. Complicating matters is the increased usage of commercial off the shelf (COTS) products and emerging computer technologies enabling dynamic allocation of software application task within the environment. Both these factors further stress current testing and certification approaches. New and innovative approaches are needed.

PHASE I: Develop new and innovative methodologies to test and certify computer software-intensive systems. Provide notional example of how methodology might be applied to a complex ship environment.

PHASE II: Refine methodology and implement associated software support and process enablers. Apply prototype testing system to a portion of total ship computing environment to demonstrate initial feasibility.

PHASE III: Transition integrated approach to ongoing DoD complex software-intensive applications including naval ship application programs. Commercialize approach to increase quality of commercial-based systems.

COMMERCIAL POTENTIAL: Testability and the ability to ensure sufficient quality of software-intensive systems continues to be an important area in the commercial community. The Internet community, companies' enterprise networks, and the telecommunications industries all have a critical need for increased ability to test and verify systems. Financial and commercial avionics/transportation-based systems especially require a high level of confidence.

KEY WORDS: Test, Certification, Software, Shipboard, Networks, Computers

N99-079 TITLE: Multi-Level Security in Advanced Computer-Intensive Environments

SCIENCE/TECHNOLOGY AREA: Computer/software

OBJECTIVE: The objective of this topic is to develop technologies to address the multi-level security within a complex software-intensive system environment. Of particular concern is the ability to maintain multi-level security while support robust ability to migrate and reallocate software task through a complex computer network architecture.

DESCRIPTION: Computer system plant, such as the one envisioned for the next generation surface combatant, DD21, will provide

support for the breadth of computational needs within the ship. Advanced operating systems, resource management systems, and message middleware is facilitating the ability to quickly reconfigure software and hardware components to react to changing mission (needs), faults to software or hardware, and changing resource requirements. The dynamic nature tends to be counter to the approaches to support multi-level security; however, information within such a complex environment will include multiple levels of security classification, with varying need to know by operators and crew members. This will be especially critical as crew sizes decrease in new ship classes. The intended approaches would leverage current multi-level security technology, evolving where possible, redesigning when needed.

PHASE I: Design and develop concepts for multi-level security approaches which will be fully operative in the future total ship computer environments. Investigate system solution, including hardware, software and processes necessary to implement conceptually design.

PHASE II: Continue to refine and prototype the conceptual approach. Perform trade-off studies of competing designs. Implement prototype system and demonstrate initial feasibility.

PHASE III: Integrate approach into emerging computer system architectures and demonstrations of advanced shipboard computer environments. Begin production to wider commercial audience.

COMMERCIAL POTENTIAL: Multi-level security is becoming a real concern within the telecommunications, banking, and internet commerce. Technologies developed within this effort should be directly commercialized and marketed within these communities. The commercial sector has an immediate need for these capabilities.

REFERENCES:

1. Computer System Security B An Overview: http://www.sei.cmu.edu/str/descriptions/security_body.html
2. DoD Trusted Computer System Evaluation Criteria, DOD5300.28_STD, December 1985, available at http://www.radium.ncsc.mil/tpep/library/rainbow/5200.28-STD.html

KEY WORDS: Security; Computer; Integration; Network; Shipboard; Resource Management

N99-080 TITLE: Affordable Wideband Radar Receiver

SCIENCE/TECHNOLOGY AREA: Electronic Warfare

OBJECTIVE: To design, develop and demonstrate an active phased-array radar receiver utilizing true time delay beamforming technology. The concept must be scalable to large antennas with 10,000 or more elements, maximally leverage currently available Commercial of the Shelf (COTS) technology and entail affordable insertion and life-cycle support costs.

DESCRIPTION: Future naval combat systems will include phased-array radars with wide instantaneous bandwidth for high range resolution, target detection and discrimination functions. However, such functions cannot be supported by presently employed beamsteering techniques (e.g. frequency scanning and electronic phase-shift steering). A minimum ten-fold increase in bandwidth can be achieved by implementing true time delay (TTD) beamsteering. However TTD demonstrations to date have not demonstrated scalability to large systems. The following technical objectives should be incorporated in a TTD-steered phased array receiver:

Active array dimensions at least 1 x 64 elements; +/- 65 degree scan angle; 4 dB noise figure; 70 dB-MHz dynamic range; Minimum time delay resolution of 1ps; 1micro second reconfiguration time; Extremely high phase stability; Scalability to large arrays

PHASE I: Develop and evaluate receiver concepts on the basis of both performance and cost, considering application to the 64 element (minimum) PHASE II array and a hypothetical 10,000 element array. A laboratory demonstration is desired. From evaluation results, prepare specifications and acceptance test procedures for components for proposed active array.

PHASE II: Procure and test components for compliance with established specifications and assemble components into prototype beamformer. Package beamformer for insertion into a test vehicle. Perform near and far field testing of receiver. Provide simulated radar returns to evaluate receiver performance in hostile and/or cluttered environments.

PHASE III: Full development of wideband microwave transmitter/receivers for military and commercial applications.

COMMERCIAL POTENTIAL: Wideband phased arrays are increasingly used in commercial satellite/wireless communication

systems. Analog receiver technology developed for this SBIR topic could be easily adopted to such digital commercial applications.

REFERENCES:
1. R.J. Mailloux, Phased Array Antenna Handbook, (Artech House, Boston, 1994) pp. 34.
2. Zmuda, H., and Toughlian, E.N. (eds.), Photonic Aspects of Modern Radar, (Artech House, Boston 1994)

KEY WORDS: Radar; beamformer; receiver; antenna; beamsteering; wideband

N99-081 TITLE: High Speed 2x2 Optical Switches

SCIENCE/TECHNOLOGY AREA:: Electronics

OBJECTIVE: Develop a compact 2x2 optical switch suited for fiber optic microwave distribution applications.

DESCRIPTION: Optical switches are needed for wide instantaneous bandwidth radars. Current optical switches cannot simultaneously meet all anticipated performance requirements. The proposed 2x2 optical switch should have low (1 dB) insertion loss, sub-microsecond switching time, >55 dB return loss, and >55 dB optical extinction, and good temporal and temperature stability.

PHASE I: Develop and evaluate a compact, high speed, high optical power switch. The device must respond to sub-microsecond control signals and be appropriately packaged. A hardware demonstration is desired.

PHASE II: Develop, test and demonstrate the proposed optical switches.

PHASE III: Full development for commercial, military and university research applications is envisioned.

COMMERCIAL POTENTIAL: This optical switch would be of great benefit to commercial industries involved in analog optical communication systems, such as millimeterwave fiber-optic feeds for indoor wireless and also satellite-based phased array antenna development.

REFERENCES: Zmuda, H., and Toughlian, E.N. (eds.), Photonic Aspects of Modern Radar, (Artech House, Boston 1994)

KEY WORDS: optical switch; microwave distribution; high speed;high isolation;high extinction;analog transmission

N99-082 TITLE: Assessment of Reduced Manning Impacts on Ship Crew Operational Effectiveness and Computer Resource Requirements

SCIENCE/TECHNOLOGY AREA: Manpower, personnel, and training

OBJECTIVE: Develop a capability which will enable commanders, evaluators, and mission planners in real time to determine the impact of reduced manning availability on human error potential, crew workload, total ship computational workload and operational performance effectiveness for selected mission scenarios.

DESCRIPTION: The Navy is faced with two challenges in the operation of existing and future surface ships. First, human error continues to represent the major threat to safe ship operation, accounting for about 80% of Navy ship accidents. Second, future Navy ships will be manned with significantly fewer crew members than existing ships. With Smart Ship, existing ships will also be re-designed and reconfigured for manpower reductions. A major concern in the acquisition of reduced manning ships, or in the reduction of manning in existing ships, is that ship personnel maintain required levels of operational effectiveness across all projected missions and mission conditions. This includes the assurance that the fewer personnel manning Navy ships will be fully capable of performing required tasks in normal and emergency conditions, and will commit fewer errors and cause fewer accidents as compared to present day ships. To ensure that operational effectiveness is not compromised in a reduced manning environment, advanced technologies will be employed to assess performance capabilities, the potential for human error, crew workloads, and impacts of the total ship computer resources for specified mission scenarios in reduced manning conditions. Capabilities addressed in this topic will include: play out what-if analysis to assess the impact of mission scenarios on ship, system, computer plant requirements, and

personnel capabilities, including human error potential, crew workloads in an operational, reduced manning environment; support real-time mission planning exercises where the emphasis is on ensuring that available resources, including manpower and computer resources, are most effectively employed and deployed for specified missions; provide real-time manpower planning during periods of conflict where crew incapacitation or system degradation will further impact crew workloads and workload distributions; support determination of the impact of proposed modifications to existing or projected ship systems on personnel performance capabilities, error potential, computational workload and crew workloads. The elements of the capability will include an interactive task network simulation capable of analyzing missions over all phases of a ship's operational cycle (combat, training, in-port) and defining mission outcomes and human performance capabilities and workloads for selected mission scenarios; a scenario generator capable of modifying subroutines and process variables associated with standard mission scenarios to achieve a set of tailored scenarios which address the problem at hand; algorithms, process variables and subroutines for estimating the probability of human error, and determining the impact of specific errors on operational effectiveness; and a highly usable display capability which will readily support the effective configuration of scenarios, and present a meaningful display of parameters at selected time points or events in the scenario, understandable by operational commanders, evaluators, and planners with little or no formal training in the implementation technologies employed.

PHASE I: 1) identify and describe specific applications and develop concepts for manning assessment within those applications; 2) develop and produce a set of functional requirements for each application, including user activities and decisions, and program information, performance, decision, support, and interface requirements; 3) develop and produce a functional specification for the analysis capability, and 4) develop and produce prototype display screens for specific applications.

PHASE II: Produce the analysis software, procedures, standard scenarios, heuristics for tailoring the scenarios, and display generation capabilities needed to meet the need, and will demonstrate and evaluate the developed capability to determine performance and workload impacts of mission scenarios, and the capability to simulate the user quickly and accurately.

PHASE III: Apply the developed capability to advanced ship acquisition programs including DD 21, LPD-17, and MFSS Demonstrator, and will acquire data on the capabilities and limitations of the operational simulation for specified applications. The capability will also be applied to existing ships, including Smart Ship, Gator 17, Smart AOE, Smart Base, DDG-51, and CVNs.

COMMERCIAL POTENTIAL: The capability will have direct application to the problem of maintaining operational effectiveness of a complex system after downsizing, and will be especially useful to commercial enterprises facing the same performance constraints as the surface Navy, and where human performance is critical to safe and effective system operation. Examples of potential commercial users of the modeling and simulation include commercial ship owners and operators, the off shore petroleum industry, chemical process control systems, and nuclear power plants.

REFERENCES:
1. Bea, Robert G. (1994) The Role of Human Error in Design, Construction, and Reliability of Marine Structures, U.S. Coast Guard Ship Structure Committee.

2. Malone, T.B., Baker, C.C., Anderson, D.A., Bost, J.R., McCafferty ,Jennings, M., Noreager, J., and Terry, E., (1996) Human Error Reduction through Human and Organizational Factors in Design and Engineering of Offshore Systems, 1996 International Workshop on Reduction of Human Error through the Application of Human and Organizational Factors in Design and Engineering, New Orleans, LA., December, 1996.

KEY WORDS: Human error; reduced manning; human workload; total ship computational workload; operational performance effectiveness; crew workload

N99-083 TITLE: Multi-Disciplinary and Multi-Sensor Integrated Display Development

SCIENCE/TECHNOLOGY AREA: Sensors, Software Computing

OBJECTIVE: Develop new display formats that facilitate multi-disciplinary and multi-sensor presentation of data on reduced manpower 21st century surface combatants.

DESCRIPTION: Proposed manpower limitations on the new surface combatants will require the use of innovative combat system display techniques. Operators from multiple disciplines will be required to use a common set of displays that will present multi-

sensor data throughout the ship. These displays must present an integrated picture of multiple sensor data including (but not limited to) active sonar data, electronic warfare data, radar data, and passive sonar contacts. A common display concept is vital to the multi-disciplinary aspect of this system. Interfaces to the various sensor systems are necessary to include their data on a common set of displays. The displays should give the operator access to data, not only contacts, without requiring the operator to drill down into unfamiliar display systems; The displays should be capable of presenting data and contacts in an effective and efficient manner. Consideration should be given to the ability to overlay multiple data types (at the contact or data level) effectively, and the presentation of logical guides to orient the operator to the scenario quickly. Development of automation type tools to help operators manage and follow multiple data types on the display is vital.

PHASE I: Formulate a display design concept, including basic formats, operator-machine interface philosophy, data connectivity, and data integration concept.

PHASE II: Prototype the proposed display concepts on a commercial workstation, using simulated data and stored sensor data. Include sufficient functionality to clearly demonstrate the integration of data presentation from multiple sensor systems, and demonstrate operability.

PHASE III: Implement fully the proposed multi-sensor display system in a combat system test-bed or development facility, including connectivity to real data from multiple sensors. Demonstrate the data integration and operability features in a realistic environment of real time multi-sensor data inputs.

COMMERCIAL POTENTIAL: The data fusion and multi-disciplinary display concepts developed under this topics may be useful in many areas where human operators are required to perform complex simultaneous tasks based on multiple real time data inputs. Examples include air traffic control, stock/commodity trading, aircraft piloting, and police dispatching.

REFERENCES: Tufte, Edward R., The Visual Display of Quantitative Information, Graphics Press, Chesire CT, 1983.

KEY WORDS: Display; Computers; Operator-machine interface; OMI; Combat system; Sensor data

N99-084 TITLE: Adaptive Mainbeam Cancellation Technique

SCIENCE/TECHNOLOGY AREA: Electronic Warfare

OBJECTIVE: The objective of this proposal is to develop a practical, affordable, technique to achieve effective cancellation of narrow, or wideband, jamming interference in the mainbeam regions of solid state, active aperture radars, while retaining significant capability for detection and angle measurement.

DESCRIPTION: Antenna based electronic counter counter measures (ECCM) techniques are far more robust in the sidelobe region than in the main beam. Low design sidelobe levels simultaneously provide for substantial innate rejection margins, and for simpler architectural requirements for implementation of adaptive cancellation systems. In contrast to the above, mainbeam jamming enters the receiver largely unattenuated, and requires expensive, full gain, auxiliary patterns, to cancel adequately. In addition, after such cancellations are effected, the mainbeam patterns are likely to become sufficiently distorted, to seriously degrade both detection sensitivities, and angle measurement capabilities. Since radar trends indicate ever-increasing sensitivity requirements, the deleterious effects of electronic counter measures (ECM) will also increase, in direct correspondence, unless adequate countermeasures are provided for in the original designs. Front end countermeasure solutions are to be thought of as integral parts of future active array architectural designs.

PHASE I: Develop one, or more, innovative techniques to effect practical, operationally meaningful, mainbeam jamming cancellation in solid state, active array, radar architectures. Develop the attendant architectural requirements, and analyze the detection and angle measurement performance via a computer simulation, against both narrow and wideband jammers. Use the results to demonstrate the feasibility and practicality of such solutions.

PHASE II: Demonstrate and validate these techniques using an existing active phase array, in an existing test bed. The array can be an operational array, or a prototype under development.

PHASE III: Insert this new technology into one, or more, active array programs within the Navy community, or within another branch of the U.S. military.

COMMERCIAL APPLICATIONS: The technology developed within this project can become an integral part of many future solid-

state-active-array radar designs within the commercial community. These can involve a variety of applications, i.e. shipboard, airborne and ground based radars. The technology is also applicable to reducing interference on satellite systems and digital cellular base stations.

KEY WORDS: adaptive processing; mainbeam cancellation; jamming; active aperture; radar; electronic counter measure

N99-085 TITLE: Space Time Adaptive Processing for Advanced Phased Array Radar Systems

SCIENCE/TECHNOLOGY AREA: Electronic Warfare

OBJECTIVE: Demonstrate improved performance of advanced phased array radars for shipborne applications by implementing Space Time Adaptive Processing (SRAP) Techniques. Demonstrate that similar techniques can be applied to commercial systems such as imaging radars, communications systems (e.g. satellite and cell phones), and to satellite navigation systems.

DESCRIPTION: With the maturing of phased array and radar processing technologies, Solid State Active Array (SSAA) radars can be expected to play an increasingly larger role in advanced radar systems. SSAA radars can provide significantly greater performance. For example, they can dynamically position multiple antenna beams to steer around mainlobe jammers, allocate a higher percentage of the dwell time on high priority sectors, and dwell on selected high priority (threat) targets for extended periods of time. STAP has been identified as a key technology that can optimize the sidelobe levels in an SSAA to minimize clutter and jammer returns, and thus provide improved detection performance of small targets in the presence of severe clutter from littoral environments and jamming. STAP techniques can also be used to reduce the clutter spread due to ship motion and to cancel advanced jamming signals such as mainlobe scattered interference (MSI). STAP refers to the extension of standard adaptive antenna techniques to processors that simultaneously combine signals received on multiple elements of an array (the spatial domain) and multiple pulse repetition periods (the temporal domain) of a coherent processing interval. STAP offers the potential to improve radar performance in several areas. First, it provides a robust approach that can simultaneously attenuate interference from multiple sources including jammers (directed and reflected path), friendly interference, clutter, and own shipboard interactions. Second, it offers low and medium pulse repetition frequency (PRF) systems improved low velocity detection through better mainlobe clutter suppression. And third, it offers an adaptive strategy for handling a non-stationary interference background, as is often found in littoral environments.

PHASE I: Develop a STAP technique to improve shipboard SSAA radar performance in clutter and jamming. Provide top level assessment of implementation issues both in the antenna and processor areas.

PHASE II: Perform an in-depth analysis of processor throughput requirements for STAP. Evaluate commercial off the shelf (COTS) processor implementations. Demonstrate the algorithm processing capability with a non-real time COTS demonstration.

PHASE III: Provide a real time COTS processor demonstration of STAP.

COMMERCIAL APPLICATIONS: STAP technology can provide improved performance in clutter and jamming/interference to a wide range of military and commercial radar and communications systems. Ground mapping synthetic aperture radars (SARs) are being developed to perform a host of tasks, including earth resource mapping, crop monitoring and disaster assessment. The cost of re-flying a mission if data is lost due to Radio Frequency Interference (RFI) makes STAP a cost effective solution. Additionally, SARs (operating at UHF and capable of penetrating foliage), are being used to collect important data. These radars are subject to a wide variety of RFI, including radio and television signals. Ground Positioning System (GPS) Systems are needed to provide accurate position and navigation data in critical civilian applications. Air traffic control will require using STAP techniques to reduce both intentional interference and unintentional RFI. Airborne radars, digital cellular base stations and satellite systems are candidates as well. STAP will be extremely valuable in these systems.

KEY WORDS: adaptive processing; phased array; radar; electronic counter measure; jamming; clutter suppression

N99-086 TITLE: Development Of 5 Micron Self Cleaning Fuel Oil Filter

SCIENCE/TECHNOLOGY AREA: Materials

OBJECTIVE: To develop a filter, which is rated for 5 micron but also is self cleaning. This self-cleaning feature reduces maintenance manhours on the ship's crew plus significantly reduces the HAZMAT issues.

DESCRIPTION: DFM which is the fuel used on all navy ships has a significant amount of debris in the 5 to 25 micron level. The gas turbines used to power our ships have to have fuel which does not have greater than 10 microns. The filter separators used to condition fuel i.e. Remove debris and water, have passages which are as low as 5 microns. This small passage requirement is needed to assure the separation function is effective. In order to eliminate the need to periodically replace the filter separator elements, a prefilter upstream of the separator unit is needed. Having a self cleaning 5 micron prefilter would reduce material costs, maintenance man hours, reduce hazards associated with having open pressure vessels containing fuel exposed to the personnel and shipboard equipment. The filter should be sized for 135 gpm, at 100 psig, with a debris removal rate of 10-mg/l with particle sizes ranging from 5 to 25 microns.

PHASE I: Develop a proposed concept or scheme for self cleaning removal of particulate material from 5 to 25 MICRON level, inclusive, from Diesel Fuel to demonstrate the feasbility of accomplishing the objective.

PHASE II: Prepare a layout of the design with actual sizing of components plus selective testing of filtering components, and fabricate and demonstrate a prototype.

PHASE III: Construct a full sized unit and perform laboratory testing.upon satisfactory lab tests, install the unit onboard a naval ship for operational testing.

COMMERCIAL POTENTIAL: All commercial ships, petroleum industry, shore side power plants, and processing plants that use fuel or lubricating oils in their operation could benefit from this development.

KEY WORDS: strainers; filters; self-cleaning; 5 microns

N99-087 TITLE: Development of Improved Non-Skid Coating

SCIENCE/TECHNOLOGY AREA: materials and structures

OBJECTIVE: To develop a non-solvent based non-skid that will last longer (including improved jet blast resistance) than the current solvent based non-skid systems. The new non-solvent based non-skid must be able to improve and reduce overall life cycle cost to the Navy. The new non-skid surface must be environmental compliant, wear resistant, corrosion resistant, and a have a coefficient of friction (slip resistance) of a minimum of .90 dry, .85 wet, and .75 oily.

DESCRIPTION: Todays non-skid have very limited life. This SBIR proposes to develop a much longer life non-skid that uses refractory materials. The non-skid shall have metallic or nonmetallic materials combinations thereof which exclude normal paints based materials such as hydrocarbons, silicone, or halide technology and shall withstand the increased exhaust temperatures of 700 degrees F or higher and mass flows associated with future aircraft engines.

PHASE I: Develop a non-skid system, which provides the attributes described above.

PHASE II: Develop/ implement plan to test non-skid system on active navy ship platforms.

PHASE III: Develop appropriate specifications/documentation to make the system standard in the fleet.

COMMERCIAL POTENTIAL: Improved non-skid coatings can be applied in the commercial shipping industry, on drilling platforms, to improve walking surfaces (steps, subway stations, and ramps), and for recreational applications (theme parks, swimming pool decks, tennis courts etc).

KEY WORDS: Non-Skid, Coatings, Flight Decks

N99-088 TITLE: Reliability of Watertight Boundaries

SCIENCE/TECHNOLOGY AREA: Materials and Structures

OBJECTIVE: To assess the structural reliability of the decks and bulkheads forming watertight boundaries of vital spaces and develop structural design criteria that will provide a level of reliability that is consistent with damaged stability criteria.

DESCRIPTION: Structural boundaries of spaces essential for survivability are based on historical practices that do not consider the probability of design loads being exceeded. Certain flooding conditions that would occur after damage to the ship, which could result in loads that could cause structural failure and progressive flooding, causing the loss of the ship. The reliability of these structural boundaries (so-called secondary structure) has not been addressed in research efforts to date, but is important for survivability from damage.

PHASE I: Develop a framework for the assessment of the reliability of the structural boundaries of flooded spaces. Identify the tools to be used to compute wave heights, ship motions, and the ensuing loads on the structural boundaries. Identify the tools necessary for determining the ultimate strength of the structure and the probability of failure. Demonstrate the approach by evaluating a sample case, using linear approximations as necessary.

PHASE II: Develop the tools identified in PHASE I, and use them to assess the reliability of the structural watertight boundaries of at least three different ship types. Using the results of the analysis, develop a procedure for use in ship structural design that will provide a uniform level of reliability for these structural watertight boundaries.

PHASE III: Improve and document the computer programs developed in PHASE II so structural designers can routinely use them. Use these tools in a ship design environment and demonstrate the improved capability of the ship when designed with the new criteria.

COMMERCIAL POTENTIAL: The computer programs developed will require maintenance to add features that users will identify, including interfaces with other ship design computer programs. With acquisition reform, naval ship designs will be performed by private contractors, and the computer programs will be sold to them. Because the subject of the reliability of flooding boundaries is not addressed in the design of commercial ships, there is a great opportunity for the use of this design procedure for those ships.

REFERENCES:

1. Ship Structure Committee Report SSC 392, Probability-Based Ship Design: Implementation of Design Guidelines
2. Ship Structure Committee Report SSC 398, Assessment of Reliability of Ship Structures

KEY WORDS: Structural reliability; damaged stability; watertight boundaries; bulkheads; decks; flooding.

N99-089 TITLE: An Automated Shipboard Cargo-Handling System

SCIENCE/TECHNOLOGY AREA: Manufacturing

OBJECTIVE: To develop a modular system for automated handling of cargo aboard commissioned Navy and Military Sealift Command ships.

DESCRIPTION: In order to achieve automated cargo handling aboard naval ships, it is proposed that an automated storage and retrieval system (AS/RS) be developed for use in a cargo hold, magazine, and storeroom of a ship. It should be modular, in that the same basic components will fit into large holds/magazines or small storerooms, with only a difference in the number or scale of sections or modules pieced together. The system will receive and deliver a pallet and/or a case to the user on demand, will track the entire inventory within the system, will provide real time status reports, and interface with supply systems on other ships and ashore. Reliability, maintainability, and availability (RMA) factors are critically important to the system. It must be extremely durable for shipboard use and be fully operable in an at-sea environment.

PHASE I: Develop a concept design and prototype the system via Modeling and Simulation to meet the requirements of a designated NAVSEA Technical Point of contact (TPOC). Simulate the design in multiple configurations to show modularity. NAVSEA will select the participating TPOC in order to bound the problem.

PHASE II: Develop and engineering design package of the system within a selected ship. Model sea-environment forces to show that the proposed system is acceptable for shipboard use.

PHASE III : Develop the detail design for the AS/RS system, fabricate a prototype and install it in a testbed aboard ship.

COMMERCIAL POTENTIAL: This system will advance the state-of-the-art in existing AS/RSs by at least one generation in shoreside systems. It will have direct application to the cruise ship industry.

KEY WORDS: Automated cargo handling; AS/RS; pallet storage; palletized cargo; automated warehouse; shipboard automation

N99-090 TITLE: Advanced Monitoring and Diagnostics of Valves and Actuators

SCIENCE AND TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop/investigate Condition Based Maintenance (CBM) technology to predict and reduce impending valve and actuator failures.

DESCRIPTION: Valves and their actuators are the controls for fluid systems. As with other piping components, the health of valves and actuators deteriorate with time. Unexpected failures of a critical valve can shut down vital fluid systems. The nuclear power industry has developed a non-intrusive, condition based maintenance solution to forecast impending failures of automated valves. The technology relies upon use of equipment mounted sensors that will collect the Asignatures of the valves and their actuators in real time, and predict impending failures by providing early warnings. Currently, the equipment for data gathering and interpretation is rather bulky and very expensive for use in non-nuclear applications. This task would develop both hardware and software innovations that will significantly advance the technology resulting in reduced cost and size, and reduced maintenance for valves and actuators on board naval vessels in non-nuclear applications.

PHASE I: Research and develop an affordable condition-based monitoring and diagnostic sensors and system embodying technology improvements to achieve reduced costs and size. Select optimum technology, reduce the size of sensors and related equipment to acceptable shipboard levels, determine data sampling rates, and integrate with the current Navy ICAS system. Both portable as well as on-line mounted equipment will be addressed.

PHASE II: Implement the concepts of Phase I, including the design, development and testing of prototype sensors and systems. Conduct detailed cost analysis of the technology, and its return on investment. Determine all elements of CBM which are necessary to implement the technology on naval shipboard fluid systems.

PHASE III: Aboard Naval ships and in commercial applications the maintenance costs for fluid systems are many times more than the cost of the original equipment. Often, the cost of a plant shut down due to a faulty valve can be in hundreds of thousands of dollars a day. Condition based equipment, which can accurately predict failures, are a near-term requirement, and will be installed and specified as soon as available. As such, US Navy, commercial power plants, chemical process industry, petroleum and refining industry, and others that are big users of automated valves stand to benefit by the successful development of this technology.

COMMERCIAL POTENTIAL: This technology has direct application to commercial ships, power plants, chemical process industry, petroleum and refining industries.

REFERENCES: R.C. Rittenhouse, Valves, Valve Materials and Testing meet tougher demands, Power Engineering, January 1991. William O'Keefe, Power Plant Valves, Power, May 1990. William O'Keefe, Monitoring Valves, Actuator Performance, Power, July 1988. R.C. Rittenhouse, Electronic Data Systems, Plant Engineering Magazine, May 1991 Instrument Society of America, ISA Handbook of Control Valves, 2nd Edition

KEY WORDS: Condition Based Maintenance; Valves; Actuators; Sensors; Electronics Advanced Monitoring, Diagnostics; Signatures

N99-091 TITLE: Non-Destructive Testing (NDT) Method for Locating and Plotting Flaws in Elastomer Components

SCIENCE/TECHNOLOGY AREA: Materials/Processes/Structures

OBJECTIVE: Develop a method to determine the size, orientation, and location of flaws found in elastomer components.

DESCRIPTION: The technology to accumulate and store significant levels of strain energy in an elastomer has been demonstrated by the inflation of large (8" diameter, 10 thick) disks, spheres, etc. The need to accurately locate small flaws (1/8" x 1") introduced during fabrication below the surface of the elastomer part is critical to the safety, operational performance, proof testing, and quality assurance of such parts. This effort would use the innovative implementation of existing and new technology to design and fabricate a suitable sensor system for the above application.

Existing methods used for NDT include low frequency ultrasonics, xerography, tomography, and fluoroscopy. Ultrasonic methods are well suited for measuring the thickness of a rubber part, but have difficulty in conveying the orientation, overall size, and type of the flaw. X-Ray methods such as xerography and fluoroscopy have been used to locate flaws, but their accuracy is susceptible to the orientation of the flaw with respect to the X-Ray beam.

PHASE I: Develop innovative concept design(s) and a breadboard demonstration in sufficient detail to assess performance and cost of a manufactured device.

PHASE II: Fabricate prototype device and conduct in-situ evaluations with actual or elastomer components. Optimize performance and accuracy while maximizing repeatability.

PHASE III: Manufacture production device packages including operating instructions and specifications. Sell devises to Navy and/or manufacturer of Elastomeric Ejection System components, or other highly strained elastomeric components, for production quality control, product acceptance tests, and in-service quality inspection.

COMMERCIAL POTENTIAL: The use of elastomers and rubber materials in industry and consumer products is ubiquitous. Flaw locating and plotting capabilities will not be limited to highly strained disks and spheres. This technique will enable manufactures to routinely inspect prototypes during product development as well as production and in service hardware.

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1. Halsey, G.H., Nondestructive Testing, Rubber Age, February, 1968.
2. Dodge, D.D., Principles and Applications of Non-destructive Testing, American Society of Mechanical Engineers, Paper No. 61-WA-323, 1961.

KEY WORDS: Non Destructive Testing; NDT; sensor; elastomer; transducer; rubber

N99-092 TITLE: Prediction of Prototype Hydrodynamic Performance

SCIENCE/TECHNOLOGY AREA: Software & Hydrodynamics

OBJECTIVE: To accurately predict full scale vessel hydrodynamic performance from small scale model data.

DESCRIPTION: Develop a software-based process that accurately predicts the propulsion performance (forward speed, shaft speed, power required, vibration forcing function, appendage wakes, boundary layer turbulence, cavitation inception), and hull and appendage forces of a prototype marine vehicle system given small-scale experimental measurements. The task to meet the stated objective is configured into three phases:

PHASE I: The first phase will be to develop: (1) the physical phenomena that affects the prediction of prototype performance from small-scale data, (2) a review of the state-of-the-art for the prediction of these phenomena, (3) a prototype process that uses these prediction methods to address the task objective, and (4) an assessment of the feasibility in achieving the task objective. The range of applicability will be from length Reynolds numbers of 0.5x106 to 2.0x109. The envisaged system will meet the requirements of a designated NAVSEA Program Manager, possibly SEA 92R. NAVSEA will select the participating PM in order to bound the problem.

PHASE II: If the results of PHASE I recommend a viable process, PHASE II will focus on demonstrating that the

controlling phenomena can be predicted with sufficient accuracy. This will be done using small-scale data and available prototype data. If additional code must be integrated to address system prediction requirements, it will be developed in this phase. The validity of the process will be demonstrated using available intermediate scale (1/4) data.

PHASE III: The successful completion of PHASE II will require the application of the process to a prototype system for final verification. This will include the definition of the experiment to be conducted, conducting the experiment, interpretation of the data, and comparison with predictions.

COMMERCIAL POTENTIAL: There is the potential for application of this process to a number of vehicle applications in the marine, aerospace, commercial aircraft and energy transfer industries. These industries all use some form of model testing in prototype design to open or close the design space. Fast accurate reduction of small scale data to full scale performance will save time and money while allowing consideration of more variants and better solutions.

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1. AGARD, On Reynolds Number Effects and Simulation, Aerodynamic Data Accuracy and Quality: Requirements and Capabilities in Wind Tunnel Testing, July 1, 1988.
2. Reynolds Number Influences in Aeronautics, NASA TM-107730, May 1, 1993.
3. AGARD, Scale Effects on Aircraft and Weapon Aerodynamics, AGARD-AG-323, July 1994.
4. Halstead, D. E., Wisler, D. C., Okiishi, T. H., Walker, G. J., Hodson, H. P. and Shin, H. W., Boundary Layer Development in Axial Compressors and Turbines; Part 1 - Composite Picture, Part 4 - Computations and Analysis, Trans. ASME, vol. 119, January 1997.
5. Halstead, D. E., Wisler, D. C., Okiishi, T. H., Walker, G. J., Hodson, H. P. and Shin, H. W., Boundary Layer Development in Axial Compressors and Turbines; Part 2 - Compressors, Part 3 - Turbines, Trans. ASME , vol. 120, April 1997.
6. ONR Workshop Summary Report, Needs for High Reynolds Number Facilities to Design the Next Generation of Sea and Air Vehicles, June 18-19, 1997.

KEY WORDS: Scaling; boundary layer; computational; fluid mechanics; Reynolds number; water tunnel.

N99-093 TITLE: Electroconducting Non-Toxic Alternative Fouling Control Coatings/Systems

SCIENCE/TECHNOLOGY AREA: Materials

OBJECTIVE: The objective of this work is to produce an effective, long life (5-7 years or more) antifouling system which is completely non-toxic to the environment. The US Navy currently takes advantage of ablative antifouling coatings based on cuprous oxide. Copper input into the environment from these coatings is coming under increased regulatory pressure. The need to develop non-toxic alternatives is greater than ever. Technologies under development to address these issues include low surface energy materials, co-polymer technology, and "booster" agents. However, silicone easy release (ER) coatings are not being implemented fleet wide, and the other technologies have not been proven and/or they rely on some level of toxicity in order to be effective. Recently several technologies based on alternating current conducting systems or pulsed DC power across a conducting coating have been developed which disrupt the settlement process of marine fouling animals. These technologies will be investigated for potential application to fouling accumulation on ship hulls, in tanks, and in cooling water systems.

DESCRIPTION: Several approaches have been considered in the past including some work with a material/coating, based on zinc chemistry, at Marine Environmental Research of North Carolina. These materials form a capacitively charged surface which releases zinc ions as an effective antifoulant.

In addition, it has been reported that Mitsubishi Heavy Industries of Japan has worked with electrically conductive coatings (trade name MAGPET) which deter biological fouling of submerged surfaces by releasing hypochlorite ions. The hypochlorite ions are released from the electroconductive coating when a small electrical current is passed through it. Hypochlorite ions are formed from the seawater and they degrade relatively rapidly in sunlight. (NOTE: this form of fouling control is related to chlorination procedures, and the EPA has placed restrictions on these practices.)

A third technology involves alternating current technology and has been designed to prevent the larvae of barnacles and other marine animals from settling by deploying a high frequency electrical field on a submerged surface. This system is based upon capacitance power transfer. An insulating coating is first applied directly to the submerged surface, followed by a conductive coating

and then a second insulating coating that serves as a dielectric. Finally, electrodes are introduced to the seawater which from the other side of the capacitor. The conductive coatings and the electrodes are each then connected to an AC power source. The system induces a current within the conductive bodies of larvae to disrupt the settlement process. The system can be switched on or off, depending on the operator's needs.

Another application of the alternating current technology involves the protection of the heat exchangers and cooling water intakes by ensuring larvae entering these systems are unfit for settlement. This technology involves a combination of insulated and uncoated metal plates hung vertically in a water intake or pipe between which passes a pulsed high frequency alternating current. Any larvae present in the water will be influenced by the electric field and will be rendered unfit for settlement. Inducing the current in the larvae makes it possible to utilize pulsed alternating current with a very low duty cycle thus resulting in relatively low power consumption.

The Old Dominion University has been working in the area of pulsed DC power to affect biological cells and therefore prevent settlement. The application of electric field pulses can stun aquatic species, and at increased fields induce mortality. The system is designed to provide microsecond pulses of up to 40 kV into a low impedance (<10 1/2) load. The system consists of an 8 KJ/s power supply which charges a pulse- forming network (PFN) with an impedance between 6 and 7 1/2 depending on the inductance of the PFN. The system is discharged through a circuit to provide a pulse to match a resistive load which is connected to the PFN via a stripline.

These emerging technology areas have been known for several years, but only recently have undergone development into potentially viable systems. They offer the potential to eliminate the need for heavy metal biocides and achieve long life performance.

PHASE I: Emphasis should be on development of materials/coatings that take advantage of the emerging technology area of electroconducting materials for marine/estuarine fouling control. Focus should be on development of materials/coatings/films for use on underwater ship hulls to prevent the accumulation of marine fouling. Proposals utilizing pulsed power or electric fields to control fouling in flows will not be considered. Phase 1 focus should be on material properties and evaluation of electrical inputs including voltages, frequencies, and duty cycles. Development of a pulse generator and/or switching device should also be addressed. The components and basic design of the system shall be defined.

PHASE II: Develop a prototype of the selected design and perform small-scale field tests.

PHASE III: Optimize system. Scale-up. Seek to transition technology to fleet.

COMMERICAL POTENTIAL: These coating systems have widespread application potential. The technology has potential for use in hull coatings, protection of power plants, steelworks, water treatment facilities, desalination plants, and a range of other industrial facilities using water for cooling or process purposes. There are significant offshore applications for prevention of fouling of ballast water tanks (and preventing introduction of non-indigenous species) and water systems on ships and platforms. This technology also represents a practical approach to a long-standing problem. It appears to be environmentally compatible while also offering the opportunity to be used on-demand (ie. Unused while ship is underway), thus extending the system life.

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1. Proceedings of the Fourth International Zebra Mussel and Aquatic Nuisance Species Conference, "The Efficacy of Pulsed Electric Fields in Preventing Settlement of Zebra Mussel Veligers", 1994.
2. US Patent #5,653,052 dated August 5, 1997, "Method for Immobilizing or Killing Swimming Larvae in a Mass of Fresh Water and an Electric Trap for Practicing Such a Method".
3. Ocean Environmental Technologies, Inc. web site http://www.oet.net
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5. Schoenbach, K.H., F.E. Peterkin, R.W. Alden, III, and S.J. Beebe, "The effect of pulsed electric fields on biological cells: experiments and applications", IEE Transactions on Plasma Science, VOL 25, No. 2, April 1997.

N99-094 TITLE: <u>Development of Total Ownership Cost Parametric Assessment Software Baseline Models for Ship R&D Concepts</u>

SCIENCE/TECHNOLOY AREA: Software

OBJECTIVE: Provide Computer Simulation based assessment of future ship R&D needs through computer aided review of threats, mission requirements, existing research and development programs and promising technologies. Perform Total Ownership Cost

(TOC) Analysis of technologies which have the potential to address these Navy needs. Conduct Total Ship System TOC assessments of key technology requirements and potential technological solutions outlined by the NAVSEA Technology Assessment, Resources & Transition (TART) team. These feasibility studies will be of sufficient detail to determine the relevance and priorities of each technology with respect to Corporate NAVSEA product lines needs.

DESCRIPTION: Develop Object Oriented Modular Structures in C++ within the Parametric Analysis of Ships Simulation Model (PASS-ASSET) simulation environment. This environment will concist of PASS coupled with ASSET in accordance with the SEA 03 PASS-ASSET developed Specification for GUI and Object socket plug-ins.

PHASE I: Develop a set of three continuing base-line PASS-ASSET generated models (Destroyers, Carriers, Auxils.) with individual sets of technology needs within the existing PASS-ASSET environment. Address a sampling of critical TART team technology needs via PASS-ASSET Total Ownership Cost analysis. Deliver in concert with the NAVSEA TART team a Phase II plan outlining the near, mid and far term technology needs still remaining to be analyzed for the three continuing Baselines and the computer technology object models still required to be developed and or modified to permit systematic total ownership cost analysis of all these technologies.

PHASE II: Develop the computer object modules from the Phase I plans:
Add specified Ship Models to Databases General Benefit to Provide Common, Integrated AModel for Development; ! Build-Up Object Models Based on Physical and/or Functional Relationships Correlated With/Or Adjusted by Empirical Data Where Necessary. Perform and report to the TART team the expanded PASS-ASSET TOC technology assessments on the three continuing baselines of all the needs developed by the TART team. Prepare two annual NAVSEA Technology Needs Quantifications with their TOC Return on Investments reports for the NAVSEA TART team to assist in phase III transition planning.

PHASE III: Transition the fully developed PASS_ASSET R&D Total Ownership Cost Simulation model to SEA 03 and industry for continuing support of pre - milestone 1 ship design activities.

COMMERCIAL POTENTIAL: All Navy and commercial ships and boat design agents. The petroleum industry, Inland Barge Companies, Ferry boat operators, Towboats, Yachts companies etc. could utilize this computer based modeling capability to financially evaluate technologies impact on their products.
KEY WORDS: strainers; filters; self-cleaning; 5 microns

N99-095 TITLE: An Augmented-Gas-Turbine Propulsion Engine

SCIENCE/TECHNOLOGY AREA: Power and Propulsion

OBJECTIVE: To develop an advanced generation of propulsion engines.

DESCRIPTION: This SBIR addresses the problem of improving the performance of current surface-fleet propulsion plants. This will be achieved through the development of a hybrid gas-turbine engine incorporating combustor steam injection (CSI) and/or compressor-inlet, water-fog injection (WFI). The solution to this problem requires (1) analytical simulation of the off-design performance of these engine variants, (2) hardware tests to confirm the performance predictions, and (3) ship-impact studies to quantify the operational payoffs under a generic ship-powering profile. Specifically, the studies are to provide the overall spatial requirements, weight, and annual fuel consumption of the propulsion plant. They will also assess the plant's impact on other ship systems, such as water-management. All of the above factors will then be used in determining the ship's operational endurance and the total cost of ownership. The overall program has been subdivided as follows.

PHASE I: Develop concepts to establish the basic feasibility of proposed performance Gas Turbine, including methods for optimizing the turbine -inlet temperature (TIT) and steam-injection rate, while preventing overspeed or over-pressurization of the gas generator.

PHASE II: Develop analytical simulations of the off-design thermodynamic performance of the engine-cycle variants, which will include both WFI and WFI in combination with CSI. At discrete power levels, the fuel and water consumption rates will be computed and used to establish the annual consumption. The above analyses will be performed under second-law constraints, including thermodynamic integration of the heat-recovery steam-generator (HRSG) performance. Hardware tests of the engine variants will provide confirmation of the predicted power output, thermal efficiency, and water consumption. They will also yield the maximum WFI rate satisfying the surge and pressurization limits of the engine. These test data will then be used to produce

preliminary designs and cost estimates for the reverse-osmosis desalination plant, the HRSG, and other major components. At this point, a determination will be made on which plant variants, if any, are worthy of a final ship-impact assessment, which will include Level-1 drawings and refined data on overall plant weight, size, and cost.

PHASE III: Design and fabricate all components of a shipboard prototype of the chosen plant, which will subsequently be installed and tested at a land-based site.

COMMERICAL POTENTIAL: Since all of the plant variants enhance both power density and thermal efficiency, they would have broad application to the power utilities.

REFERENCES on CSI:

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2. Urbach, H.B., Knauss, D.T., et al., June 1997, AA Steam-Augmented Gas Turbine with Reheat Combustor for Surface Ships, ASME Paper 97-GT-254, presented at the International Gas Turbine and Aeroengine Congress, Orlando, FL.

REFERENCES on WPI:

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2. Wilcox, E.C., and Trout, A.M., 1950, AAnalysis of Thrust Augmentation of Turbojet Engines by Water Injection at Compressor Inlet, Including Charts for Calculating Compression Processes with Water Injection, National Advisory Committee for Aeronautics Technical Report 1006.

N99-096 TITLE: Low Cost Pultruded Polyurethane Composite Deck Stanchions

SCIENCE AND TECHNOLOGY AREA: Manufacturing Sciences and Technology

OBJECTIVE: To design and develop an improved, low cost composite deck stanchion for shipboard railing systems

DESCRIPTION: The Navy currently uses steel stanchions on board ships as part of the topside deck railing system. The stanchions are made of steel and require usual maintenance procedures to prevent corrosion. These steel poles have been shown to interfere with radar systems and are therefore not kept in place on radar platforms. In addition, they add to the ship signature if left in place. There have been efforts to replace the steel stanchions with composite materials, but with limited success. The prime problem has been damage tolerance of the composite part. Large impacts from cranes and heavy machinery tend to cause catastrophic failure of the composite, whereas metal parts are merely bent and can be straightened. An alternative material system such as fiber reinforced polyurethane, which is both structural and compliant, could solve the problem. A ship set of fiber reinforced polyurethane stanchions have been manufactured and outfitted for shipboard evaluation. These stanchions were filaments wound. To make these parts attractive to the fleet, a more cost-effective procedure needs to be established. Pultrusion of fiber reinforced urethane parts could potentially provide significant cost reduction which would make acquisition costs comparable to metals. The continuous pultrusion manufacturing technique is the lowest cost process in the composites industry. The purpose of this program is to develop a pultrusion technique, which uses a high strain to failure matrix material such as polyurethane (strain to failure of 300-400%) to manufacture composite parts with uniform cross section such as stanchions. This part would provide reduced life cycle costs, more damage tolerant structures which would reduce the ship signature. A Pultruded polyurethane composite deck stanchion holds the promise of enhanced performance at an affordable acquisition cost.

PHASE I: Design the composite structure including fiber format selection and orientation. Choose appropriate urethane material, which can be used in a pultrusion process. Demonstrate fabrication and structural performance of a pultruded stanchion like structure. Provide joining concepts between the stanchion and deck.

PHASE II: Develop, fabricate and test a full-scale deck railing system based in the stanchion design from PHASE I. This shall include the chain (or other) rail and stanchion end caps. The system should be tested for radar signature and damage tolerance/load carrying capability.

PHASE III: Transition to installation of the composite deck stanchion system to radar platforms and other critical locations. Transition to other naval ships such as the retractable stanchions at the elevator hangers on carriers.

COMMERCIAL POTENTIAL: Corrosion resistant systems are required in many commercial applications including marine and off shore oil applications. The use of pultruded polyurethane composite tubing, in general, has applications well beyond stanchions including low vibration piping systems and flexible torsion shafts.

REFERENCES:

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2. Ratcliffe, Colin P. and Crane, Roger M., and Santiago, Armando L., AFiber Reinforced Polyurethane Composites: Shock Tolerant Components with particular emphasis on Armor Plating, 1995 ASME Winter Annual Meeting, Nov. 12-17, San Francisco, CA.

KEY WORDS: pultrusion, composite materials, polyurethane, stanchion, impact resistant

N99-097 TITLE: Affordable NDM (Non-Distribution Media) Vacuum Assisted Resin Transfer Molding (VARTM) Processing for Large Naval Structures

SCIENCE/TECHNOLOGY AREA: Manufacturing Technology

OBJECTIVE: To develop a manufacturing process that utilizes the low cost vacuum assisted resin transfer molding process without the need for a distribution medium.

DESCRIPTION: New acquisition strategy for high technology Navy platforms is encouraging the use of composite materials, as is evident in the DD-21 Integrated Topside Design Program and as demonstrated in the AEM/S. Composite materials are an enabling technology which will provided improved stealth performance and therefore increased survivability. Acquisition costs remain a detriment to the implementation of composites into general fleet usage. The Vacuum Assisted Resin Transfer Molding (VATRM) fabrication technique has demonstrated the ability to easily incorporate internal features for improved stealth and has shown the potential for affordable composite acquisition costs as was demonstrated in the AEM/S. The VARTM process, however, is both labor and material (consumable) intensive. Touch labor is required to place infusion media which is later discarded, and should the media be built into tools, structural foam, or vacuum bags, large capital asset outlays and touch labor are again required. To streamline manufacturing and reduce costs, a process is required that eliminates these consumable wastes and touch labor associated with VARTM. The accomplishment of cost-effectiveness will require the integration of a distribution media into the actual structural materials. This would allow the elimination of consumables, large percentages of touch labor, and an overall simplified VARTM tool and bagging techniques. In addition, cores placement, which also constitutes a large percentage of touch labor, could also be streamlined as foams could be cast in place since resin grooves would no longer be required.

PHASE I: Develop and demonstrate a VARTM like manufacturing process which could be utilized to manufacture large scale (up to hundreds of square feet) cored structures using resin systems such as vinyl ester (e.g. Dow 510-A, 8084) which does not utilize a distribution medium. The potential range of skin thickness envisioned are up to 1 in. In addition, the technique should be capable of manufacturing structures with nonuniform cross section.

PHASE II: Demonstrate the low cost aspects of the manufacturing technique through detailed cost modeling/verification of the process which will be demonstrated on a structural component of the size and complexity of the AEM/S. The specific structure will be identified prior to the start of PHASE II.

PHASE III: Utilize the low cost manufacturing technique for the manufacturing of Topside structural components required for DD-21 Integrated Topside Design. This technology could be utilized for the manufacturing of structural components for numerous other platforms including decks, stacks, foundations, and small craft hulls.

COMMERCIAL POTENTIAL: Development of this process could make composite materials affordable in other technology sectors. For example, this process could be used in the manufacturing of large civil structures such as bridge decks, railroad boxcars, barges and pleasure craft.

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2. Lazarus, Paul, "Competing Composites" Professional Boat Builder , Aug/Sept. 1997

KEY WORDS: VARTM, composite materials, vinyl ester, low cost

N99-098 TITLE: Mechanical Holders for Advanced Sliding Electric Contacts

SCIENCE/TECHNOLOGY AREA: Materials

OBJECTIVE: Develop mechanical holders compatible with present state of the art metal foil and metal fiber brushes.

DESCRIPTION: Recent developments have demonstrated that metal foil and metal fiber brushes can be fabricated which have higher contact current densities than conventional graphite or silver-graphite brushes with a lower rate of wear. Metal foil or fiber brushes may have application in both commutating and non-commutating electrical machines, including advanced direct current machines such as a superconducting homopolar motor.

Metal fiber and foil brushes require lower contact pressure. Existing mechanical holders in conventional machinery are not compatible with these brushes. Current brush loading pressures are between 2.4 and 4.0 psi. Metal fiber and foil brush performance is maximized when they are subjected to a brush loading pressure of 1.0-2.0 psi. This reduction in brush loading will increase wear resistance, increase efficiency, and will in turn greatly reduce the labor and cost associated with current fleet brush maintenance difficulties.

PHASE I: Develop innovative mechanical holders compatible with metal foil and/or metal fiber brushes for use in existing and proposed electrical machines. A report will describe the basic design including the applied mechanical load, required design space, and brush replacement. However, in general, a brush loading pressure of 1.0-2.0 psi is desirable for metal fiber and foil brushes. Brush in service life for naval application motors varies greatly. Brush replacements are required as frequently as 744 hours for some DC commutating motors, while others require replacement as infrequently as 4650 hours. Because of the light loading conditions associated with the metal fiber and foil brushes, the occurrence for electrical arcing is minimized and conversely, brush life maximized. The metal fiber and foil brush provides a potential increase of in service life of 5 times that of existing brushes. Existing brush holders are manufactured from cast brass. The brush holders should accommodate movement of up to 50% of brush initial length to accommodate wear. The brush holders should be designed and manufactured to withstand orthogonal(i.e. perpendicular) forces of magnitudes on the order of 5 times as those seen by normal forces exerted on the brush at the running surface. The brushes and brush holders should be manufactured to operate in environments of 55-100 degrees centigrade during motor full load applications. Current naval application brushes are carrying current densities that range from 18 Amps/in2 to 71 Amps/in2. In the near term, the brush holders will need to be compatible with these levels of current density. However, to meet far term goals, the brushes would need to accommodate current densities exceeding 2000 Amps/in2 as demonstrated in recent studies of both commutating and slip ring brushes. Additionally, because of imposed space constraints, the brush holder thickness should be minimized to not exceed 10%-20% of the thickness of the brush running surface. The brush holder must transfer the current from the fixed armature to the sliding brush (e.g., standard pigtail) without affecting the low (1-2 psi) normal load at the running surface. Furthermore, this flexible shunt should minimize electrical loss of the brush while retaining the aforementioned travel flexibility.

Note: The parameters suggested on the previous page serve as desirable guidelines for the performance of the brush holder and not as Ahard and fast specifications. It is fully understood that the final brush holder configuration will be an optimized solution using the given performance guidelines.

PHASE II: Select the designs best suited for naval applications. Demonstrate the mechanical holders developed in PHASE I. Complete detailed design, document the required fabrication process, and fabricate a minimum eight brush holders which can be tested with either advanced fiber and/or foil brushes on an appropriate test fixture.

PHASE III: Based on the final selection of the optimum brush technology by the Navy, integrate the brushes in a fully populated mechanical holder in an operational system and verify the performance.

COMMERCIAL POTENTIAL: High performance brushes are an enabling technology for any advanced direct current electric machine. Principle applications include machinery which require high torque and loads which require high currents. High torque electric motors are used in shredding machines, paper mills and punch press drive systems. Potential transportation systems include conventional electric trains, electric cars, and magnetically levitated trains. Compact, high performance DC generators will have applications in the electroplating industry and pulsed electric welding sources such as used in the offshore drilling industry. High current, low voltage DC electric machines will provide the most efficient, reliable method of using environmentally attractive alternate low voltage energy sources such as solar, thermoelectric, and fuel cell technology.

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D. Kuhlmann-Wilsdorf and D. Alley, "Commutation with Metal Fiber Brushes", in Electrical Contacts 1988, see also IEEE Trans. CHMT Vol. 12, pp. 246-253, 1989.

KEY WORDS: Brushes; Direct Current; Slip Rings; Mechanical Holders

N99-099 TITLE: High-Speed `Hot Chip' Motherboard

OBJECTIVE: To develop a standard affordable convection cooled motherboard for very high speed commercial processors or "hot chips".

DESCRIPTION: The heat dissipation of very high speed commercial processors or "hot chips" requires forced air cooling or conduction cooling with large heat sinks. Both fans and heat sinks occupy a significant amount of space and often limit the application of the "hot chip" processors. The commercial industry (i.e. Force, Motorola) have always desired, but have not obtained, a cost-effective convection cooled motherboard. The Navy has faced similar problems in the past and addressed the issue by using unique ceramic boards in custom enclosures. However, the high cost and limited success of this approach always restricted the use to expensive, mission critical applications.

The following paragraph appears on the Intel web page: "Two big reasons why a desktop processor must be adapted for a mobile PC are heat generation and heat dissipation. If left unchecked, high temperatures can compromise the processor's and the computer's performance and reliability. The more power a chip uses, the more heat it generates. Intel develops mobile processors that use much less power than desktop processors. For example, the latest desktop 333Mhz Pentium II processor consumes almost twice the power of the 266MHz mobile Pentium II processor. Quickly removing the heat that a computer inevitably generates is difficult within the confines of a compact mobile PC. Intel has adapted desktop cooling solutions to the mobile environment by using miniature fans and heat sinks, devices similar to your car's radiator, to quickly draw heat away from sensitive components and dissipate it to the outside air."

Intel's latest family of processors requires that the devices will operate at a case temperature range of 0 degrees Celsius to 85 degrees Celsius. At 85 degrees, the necessary airflow over a processor with a unidirectional heatsink is 600 feet/minute. This is obtainable by the cooling fans used today. However the power dissipation of todays processors is half the heat dissipation of the processors that we shall see two years from now. The heat dissipation requirements of new processors shall quickly overtake the heat dissipation capabilities of mobile processor environments.

New and innovative ceramic materials and bonding agents have demonstrated improved thermal dissipation properties over the previous generation of ceramics. These technology improvements are becoming available and need to be adapted and implemented. New designs for integrated circuit carriers shall be explored with the various manufacturers. Design of the actual convection cooled motherboard shall be done with input from the major processor manufacturers. The combination of improved ceramics, bonding agents, carrier designs and the new convection cooled motherboard will support the heat dissipation requirements for "hot chip" processors. These combined technologies would provide convection cooling of these "hot chips" without utilizing large heat sinks or cooling fans. Typical space savings from the removal of fans could consist of 16 cubic inches. Ventilation requirements could drastically be reduced by two thirds. This approach would support enhanced system performance and would reduce the system cost associated with cooling the processors.

PHASE I: Develop a detailed design for a standard convection cooled motherboard for "hot chip" processors.

PHASE II: Fabricate, test, demonstrate and deliver to the Navy a prototype of the convection-cooled motherboard with

two or more of the commercially available "hot chips."

PHASE III: Fabricate and test production configurations of the standard convection cooled motherboard for "hot chip" processor applications.

COMMERCIAL POTENTIAL: The commercial applications of a standard convection cooled motherboard would include those requirements where increased processing performance is desired in a limited amount of space. Examples of these applications might include wearable computers, automotive electronics and commercial satellites.

REFERENCES:

1) Feinstein, Leo G. "Die Attachment Methods in Packaging", Vol 1 of ASM Electronics Materials Handbook. Materials Park, OH: ASM International, 1989.

KEY WORDS: Integrated; Circuit; Bonding; Cooling; Convection; Processors

N99-100 TITLE: Cost Effective Integration Methods for Large Complex Systems

SCIENCE/TECHNOLOGY AREA: Manufacturing Sciences and Technology

OBJECTIVE: Develop techniques, tools, and approaches to accomplish timely integration of complex interface intensive systems. This should include ideas for remote software and hardware debugging and problem resolution to reduce the on-site support costs, COTS Vendor interaction, improvements in data correlation methods to manage resources and schedules.

DESCRIPTION: While the use of NDI/COTS products is not a new concept to the Navy, its application to highly elaborate weapon system developments such as the NSSN C3I System surpasses earlier complexity. The NSSN C3I System will be integrated at the COATS in the shipyard prior to shipboard installation. The ability to remotely debug and resolve problems encountered during this integration is highly desired since many subsystems/components are being developed at separate and remote contractor facilities. Debugging and resolving problems encountered during system integration will require the ability to correlate data assessed from the various contractor PTR databases as well as COTS OEM databases. Accurate scheduling and prioritization of resources is critical to ensuring that integration schedules are met.

PHASE I: Develop a methodology for remotely debugging and resolving problems encountered during integration of combat systems. Develop techniques or methods that could be used to assess the various contractor and OEM databases to support problem data correlation. Research and develop OEM test equipment/tools that could be utilized for integration efforts at the COATS.

PHASE II: Design and fabricate a proof of concept system/program based upon the PHASE I efforts that demonstrates the potential of a remote debugging capability utilized in concert with data correlation techniques and resource scheduling tools.

PHASE III: Based on a successful PHASE II effort, develop a series of remote debugging, data correlation, and resource scheduling systems/programs for use at the COATS in the shipyard and the various contractor facilities to support integration efforts.

COMMERCIAL POTENTIAL: This system could be applied in any environment where large scale COTS hardware and software systems are developed/integrated.

KEY WORDS: Integration, PTR, COATS, Debug, Resources, COTS Technology, Cost Reduction

N99-101 TITLE: Submersible Velocimeter (Acoustic, Pay-out and Others)

SCIENCE/TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop a device to measure pressure, linear velocity, acceleration, position, of a projectile being launched from torpedo tubes. The device shall also be capable of measuring flow rate.

DESCRIPTION: At least two of many approaches should be considered for obtaining projectile dynamics. One (using an acoustic based method) which does not rely on line-of-sight and second using pay out of a thin Teflon type material. The acoustic method should incorporate a filtering algorithm imbedded within a programmable IC chip. The algorithm should be compatible with ALabView for Windows software and be optimized to filter ambient flow and launch related noise and determine projectile velocity, acceleration and displacement as a function of time. The second method shall incorporate two separate measurement devices for obtaining projectile dynamics, a tachometer with an optical encoder and a light emitting diode to generate displacement pulses. These and any other methods proposed should have: all data shall be passed in real-time via both analog (full bandwidth) and a serial port with an effective data rate of no less than 200 Hz; all sensors are to reside in a rugged compact waterproof housing to withstand submergence pressures up to 1000 psig. The housing will interface with either Mk 48 or Mk 42 breech door electrical penetrator inside the torpedo tube and pass data through select pins within the penetrator. The housing will enable easy access to sensors for maintenance, replacement, and repair. The payout material and spool should be readily accessible without involving disassembly.

PHASE I: Research and develop the use of off-the-shelf instrumentation and/or equipment that will enable the monitoring of torpedo displacement, acceleration, tube door pressure, and velocity during the launch process without breaking the Submarine Safety (SUBSAFE) boundary. Candidate pressure, flow, and accelerometer MicroElectroMechanical (MEMS) sensors that were evaluated by the ONR 6.2 Undersea Warheads and OSD CTIP programs will be considered. The acoustic velocimeter sensors should be remote (no contact with projectile being monitored) using acoustic-based technology and have the greatest potential for monitoring the projectile dynamics without line of sight. The pay-out velocimeter will be developed using a wire spool pay-out system which will reside inside the torpedo tube during launch. Develop preliminary drawings of a waterproof enclosure which will house the selected sensors and mate with either Mk 48 or Mk 42 breech door electrical penetrators inside the torpedo tube. Develop preliminary drawings of the cable/signal interface which will mate with the dry side Mk48 or Mk42 electrical penetrators. Any other methods proposed should use similar techniques for ship integration.

PHASE II: Finalize the design and build laboratory grade prototype using the most promising concepts identified in PHASE I. Conduct laboratory tests to include an initial proof-in period and fine-tuning series (to obtain the best signal quality and repeatability). Data will be collected in parallel with an existing Pressure Velocity Displacement (PVD) assembly to ensure displacement, velocity, and acceleration data are comparable. The units shall provide accurate, repeatable pressure, velocity, acceleration, and displacement verses time data via the tube door penetrator in real time (200Hz effective data rate).

PHASE III: Redesign prototype for compactness, ruggedness, and ease of maintenance and repair. The unit must withstand MIL-810E 516.4 Procedure IV Transit Drop Test and MIL-810E 514.4 I-3.4 20-1000 Hz 0.4G2/Hz, 1000-2000Hz -6dB/Oct at one hour per axis. The unit shall be compact (fit within the space between the breech door and the Torpedo Mounted Dispenser), designed to withstand launch pressure pulses at depth pressures up to 1000 psig. Conduct laboratory tests to proof the ruggedized prototype followed by final shipboard tests to include launching dummy torpedo shapes. Data is to be collected in parallel with an existing PVD system to ensure displacement, velocity, and acceleration data are comparable.

COMMERCIAL POTENTIAL: These units will be useful for military or commercial applications towards monitoring projectiles being launched under water without having line of sight on the projectile. The sport diving industry could utilize such a device towards determining the performance of various spear guns , snares, or retrieval mechanisms. Salvage equipment companies could use it to design industrial retrieval mechanisms or determine distance of various underwater targets.

KEY WORDS: Submersible acoustic velocimeter; non-contact velocimeter, velocimetry, projectile dynamics measurement, wire payout measurement systems

N99-102 TITLE: Automated Test & Integration Methods for COTS Hardware & Software Components

SCIENCE/TECHNOLOGY AREA: Manufacturing Sciences and Technology

OBJECTIVE: Develop an innovative approach to testing COTS and government unique components using a hot box concept for pre-integration automated testing. Other concepts may be pursued as well. Develop a prototype system that is uniquely capable of improving the logistic and testing process of individual components and/or system level components. Reductions in combat system testing and supportability will result in a significant cost and time savings to Navy developments.

DESCRIPTION: Current combat system developments are making extensive use of COTS technology that will require frequent

technology updates/insertions. Present combat system supportability requires extensive logistics material and dedicated training for maintenance and testing of complex system components. Development of a commercial test system that is capable of testing individual components and/or system level components has the potential to greatly reduce the logistics serviceability time constraints imposed upon complex systems. The ability to rapidly reconfigure the test system to support new technologies would be required. A common test system that could be utilized at Contractor Facilities, Shipyards and Depots would result in reductions in the development of logistics material and dedicated testing associated with complex combat system supportability. This will ultimately result in a significant cost and time savings to the Navy logistics supportability system.

PHASE I: Develop a feasibility study evaluating the potential savings in test, integration, and supportability cost and schedule through the use of automated test fixtures. Establish a detailed framework for the approach, identifying leveraging opportunities and other benefits of the new approach over existing processes. Identify efforts associated with the use of COTS test fixtures to improve complex combat system logistics support activities.

PHASE II: Design and fabricate a proof of concept system based upon the PHASE I feasibility study that demonstrates the potential capabilities of a component level automated test and support system.

PHASE III: Based upon a successful PHASE II effort, develop a series of component test and support systems for use in the both the development and field support activities associated with qualification, test, and evaluation of existing combat system programs.

COMMERCIAL POTENTIAL: These approaches to automated and streamlined testing are applicable to any activity that is integrating COTS products from multiple vendors or need to assess end-of-life (EOL) replacement components. Applications include all aspects of the computer industry from the personal computer to mainframe systems.

KEY WORDS: Automated Testing; COTS Supportability; Hot Box Testing; Cost Reduction, Depot Management, Integration

N99-103 TITLE: Towed System Improved Robustness

SCIENCE/TECHNOLOGY AREA: Manufacturing Technology

OBJECTIVE: Implement Innovative Materials and Manufacturing Technology to Improve Towed Acoustic Array Reliability Without Degrading Operational Performance

DESCRIPTION: Navy Towed Acoustic Array Systems as well as Geophysical Streamers are currently fabricated with the sensors, electronics, and interconnecting wires/optical fibers housed in a liquid filled hose as a water barrier and to support the hydrostatic pressure These acoustic arrays can be thousands of feet long and are towed from surface ships and submarines. This construction technique provides adequate acoustic performance, but is subject to poor reliability (mission failure) under the stresses resulting from both towing and handling system deployment/retrieval evolutions. Research into innovative applications of state-of-the-art technology (sensors, wire assemblies including connectors, optical fibers, and construction technology including non-liquid fill) is needed to improve the reliability and mission success probability without compromising operational performance. Application of this technology also should not negatively affect production nor life cycle support costs.

PHASE I: Conduct research and analytical studies to develop innovative component and/or construction technology that will improve towed acoustic array robustness, reliability, and toughness relative to normal operational exposure including at-sea towing, handling system (traction device and winch) deployment and retrieval cycles, and handling during maintenance, transportation, and storage evolutions. Specific improvements are required in ultimate strength; hydrophone and telemetry signal path integrity under bending tension and compression cycles associated with handling; exposure to seawater, chemicals, and sunlight for extended periods; improved flexural and tensile strength/reliability at modular couplings, and more reliable electrical and optical conductors and connectors. Also to be addressed in the studies are preventive maintenance and repair maintenance associated with the new technologies and components as applied to the towed array systems.

PHASE II: Fabricate and test acoustic array sections or modules employing the new technologies for performance demonstration and evaluation. These tests will include both reliability and maintenance demonstrations as well as acoustic performance evaluations under actual towing operations at a certified Navy test facility. The test and evaluation array sections also must demonstrate the ability to achieve manufacturing and life cycle cost reductions while addressing state-of-the-art technology infusion (build-test-build).

PHASE III: The technology applications demonstrated in this SBIR Project will be implemented in Navy Towed Systems Programs (forward and/or back fit) for submarines, surface combatants, and surveillance missions by the SBIR contractor or transferred to Navy Prime Contractors as appropriate.

COMMERCIAL POTENTIAL: The technology is directly applicable in the geophysical and seismic exploration industry for the design, development, and operational use of single and multiple seismic streamers.

KEY WORDS: Acoustic Arrays; Robustness; Reliability; Performance; Innovative Technology; Innovative Materials

N99-104 TITLE: Towed System Marine Life Attack Reduction

SCIENCE/TECHNOLOGY AREA: Materials, Processes, Structures

OBJECTIVE: Identify Stimuli Causing Marine Life Attacks on Navy and Geophysical Towed Acoustic Arrays and Identify Practical Modifications or Countermeasures to Prevent the Attacks.

DESCRIPTION: Navy Towed Acoustic Array Systems operate in a harsh environment and are experiencing significant operational failures resulting from attacks by marine life, particularly shark and other fish bites. It has been hypothesized that the bites are a result of low frequency vibration associated with the tow platform and/or towcable strumming, visual attraction of the array's motion through the water, electric fields associated with the array internal power and telemetry components, and smell associated with array materials or ISOPAR fill fluid. Research into the specific causes of the marine life attacks, as well as identification of potential solutions and/or countermeasures that can be implemented without degrading operational performance, are required to improve system reliability and mission success rates.

PHASE I: Conduct research and analytical studies to evaluate current design and operational parameters, including geographical areas in which the most attacks have occurred. Research the most likely sources of attraction and bite response stimulation. Based on this research and analysis, develop practical recommendations for array design, construction, and operation modifications which will make the arrays less susceptible to marine life attack without degrading operational performance. This effort also should address the application of practical active or passive countermeasures to reduce attacks by marine life during operational use.

PHASE II: Design and fabricate appropriate test components simulating the operational parameters of actual towed acoustic array systems, and conduct testing to validate and verify the attraction and bite stimuli identified from the PHASE I research and analyses. The test program also should evaluate practical changes to the array operational parameters that reduce these stimuli, and evaluate the design and use of potential active and passive countermeasures that reduce marine life attack, as recommended from PHASE I.

PHASE III: The techniques for reducing marine life attraction and bite response stimuli identified in this SBIR Project will be applied to Navy Towed Systems Programs for submarines, surface combatants, and surveillance missions by the SBIR Contractor or Navy Prime Contractor as appropriate.

COMMERCIAL POTENTIAL: The technology is directly applicable in the geophysical and seismic exploration industry for the design, development, and operational use of single and multiple seismic streamer configurations.

KEY WORDS: Acoustic Arrays; Marine Attack/Bite; Attraction Stimuli; Bite Stimuli; Reduction; Countermeasures

N99-105 TITLE: Compact Terabyte RAID Disk Subsystem

SCIENCE/TECHNOLOGY AREA:Command, Control and Communications

OBJECTIVE: Develop a multi-terabyte COTS-based, high-reliability, high-bandwidth, high-availability data storage subsystem in a 10 U 19' rackmount box suitable for submarine use. The box shall be air-cooled, shock-resistant, and support a dual ported Fast and Wide SCSI interface. The target price of a one-half terabyte (TB) array is $50,000 in the year 2000 AD. The anticipated increase

in storage at a constant cost as a function of time is linearly proportional to the industry-wide increase of disk capacity at a constant OEM cost.

DESCRIPTION: Due to the large volume of data involved, current submarine combat systems record data for mission reconstruction only to high-density removable media. This data is not accessible during normal operations, which limits the level of detail of on-board event reconstruction. This problem will become much worse with next-generation combat systems. Space, power, and weight constraints prevent current generation RAID products from storing all of the mission data on-line. A multi-terabyte capacity, low-cost, low-weight, low-volume, low-power on-line data storage subsystem would allow ready access to that data which is currently unaccessible, and greatly facilitate on-board event reconstruction.

For ease of integration, the data storage sub-system shall appear as a standard Fast-Wide SCSI storage device to each of two host processors. The dual-porting shall be transparent to the host processors, which shall use standard SCSI driver software. The target host processors are HP VME-bus processor cards running HP-UX 10.20 or higher, and Pentium II processors running Windows NT 5.0 or higher equipped with a suitable SCSI host adapter.

PHASE I: Research storage subsystem interface technologies such as "FireWire" and Ultra-SCSI, and storage technologies not limited to conventional hard disk drives. Develop a design plan for the construction of a dual channel data storage subsystem controller with a storage capacity of at least 500 gigabyte (GB) for mounting in a standard 19' equipment rack. The controller interface shall be Fast-Wide SCSI with no special drivers required on the host side. The goal is a self-contained array with on-line error correction, monitoring, and diagnostics in a 10 U package. The data storage subsystem should also be a modular as possible to facilitate on-line repair (hot-swapping of storage modules) and maintenance. If a storage module is replaced, the array shall automatically rebuild the data on the replaced module.

PHASE II: Produce a prototype storage subsystem with on-line error correction, monitoring, and diagnostic functions. Write a test plan to demonstrate hot-swappable replacement of disks and autonomous recovery of data while the array continues to operate on-line. Testing shall be done with the both of the target host processors. The target host processors are HP VME-bus processor cards running HP-UX 10.20 or higher, and Pentium II processors running Windows NT 5.0 or higher equipped with a suitable SCSI host adapter.

PHASE III: Production of selected solution. The production units shall comply with military environmental standards when properly mounted in an NSSN SEI or equivalent enclosure. The target price for a 0.5 TB array in the year 2000 AD is $50,000, with capacities at a constant cost increasing linearly with the industry-wide increase of disk capacity at a constant OEM cost.

COMMERCIAL POTENTIAL: This SBIR topic would have potential commercial application to systems requiring on-line storage requirement. (Libraries, WEB Servers)

KEY WORDS: Data Storage, RAID, Hard Disk, Information Systems

N99-106 TITLE: Apply State of the Art Technology to Submarine Systems Maintenance

SCIENCE/TECHNOLOGY AREA: Manpower and Personnel Systems

OBJECTIVE: Develop and apply technologies to automate the maintenance of submarine systems inclusive of telepresence/virtual reality. A portable watchstander digital assistant device should be considered as an element of the telepresence/virtual reality system. Application of telepresence and virtual reality technologies for supporting submarine systems maintenance by allowing supervisory personnel to remotely view maintenance activities, in a wide variety of maintenance procedures (virtual/synthetic environments). The portable, easy-to-use digital device, should enhance the situation awareness and thus effectiveness of submarine non-propulsion watchstanders/maintainers.

DESCRIPTION: Maintenance on submarine systems can often occur in limited access environments. In those situations, telepresence, would allow others to view the work area while maintenance/repair is being conducted. One application would have the digital/audio/video device be man-mounted. Another application could be in a non-man-mounted form, such as mechanical arm or robotic device. The telepresence data could be viewed conventionally, on a monitor, or less conventionally, using "virtual-reality" headsets. Virtual reality would allow for repairs or maintenance of equipment that must remain "on-line" or is in hazardous environments.

Recent advances in portable computing make clear the potential for hand-held devices, which can support tactical and non-propulsion engineering watchstanders aboard submarines. Currently, information for watchstanders not assigned to a specific console must be captured and managed through status boards, log sheets, and other non-electronic means. Such schemes typically make difficult such critical functions as trend analysis, "what if" exercises, and data fusion across multiple sources. A portable digital device used dually for watch standing data support and telepresence/virtual reality would provide a resource for Technical Assistance, watchstander training as well as enhanced data fusion. Use of this device and the information gathered could give a supervisor a virtual status of the entire ship.

PHASE I: Research and define requirements and execute preliminary design of one or more telepresence and/or virtual reality solutions which includes watchstander support. Include the necessary hardware and software elements.

PHASE II: Produce/Develop a prototype "unit". Demonstrate functionality in controlled lab conditions. Further demonstrate functionality onboard a vessel. Also plan for cost effective production of the unit.

PHASE III: It is expected that the contractor will undertake the production and commercial sale of the successful device.

COMMERCIAL POTENTIAL: The technologies developed in Phase II will have applications in the private sector for system maintenance. A portable device which allows operations personnel to become more attuned to their duties has benefits in any process-intensive industry. Examples include manufacturing, power plant operation, and telecommunications system operation.

KEY WORDS: virtual reality; telepresence; maintenance; situation awareness; watch station; tactical decision aid; submarine; watchstander; portable digital assistant

N99-107 TITLE: Environmentally Friendly Fill Fluid

SCIENCE/TECHNOLOGY AREA: Chemistry

OBJECTIVE: Develop or identify an environmentally friendly fill fluid to replace currently used hazardous fluids. It must be non-reactive with a variety of materials, electrically non-conductive, thermally conductive and less dense than seawater. It should also be non-toxic, and not have any special handling requirements.

DESCRIPTION: The Navy currently uses synthetic and petroleum based oils as fill fluids in various undersea applications. Most of these oils are hazardous to the environment and humans. Some of them are also extremely flammable if allowed to evaporate. The Navy would like to replace these fluids with more benign materials in future systems.

PHASE I: Develop or identify an environmentally friendly fill fluid. It must have similar density, viscosity, and other physical properties as currently used fluids. It must also be non-reactive with electronics, polyurethane, Kevlar, and other materials used in Navy systems.

PHASE II: Produce some sample fluids, and demonstrate that they meet the Navy's needs. Perform material and acoustic compatibility studies.

PHASE III: The fluid developed in Phase II will be produced for use in future Navy towed array systems for submarines, surface combatants, and surveillance missions by the SBIR Contractor or Navy Prime Contractor as appropriate.

COMMERCIAL POTENTIAL: The commercial market always has use for new environmentally friendly products. The oil industry also has some similar systems to the Navy's that use fill fluids of this type.

KEY WORDS: fill fluid; environmentally benign; non-flammable; oil; non-reactive

N99-108 TITLE: Network Based Training

SCIENCE/TECHNOLOGY AREA: Computer Science

OBJECTIVE: Develop an innovative network centric training device concept based on the latest Commercial off the shelf (COTS) which provides a common hardware environment and software to support existing display formats and Operator Machine Interface

(OMI) for sonar sets, other sensors and Command and Control functions.

DESCRIPTION: Providing realistic sonar, command and control analysis' has been a top Navy priority for more than 40 years. Many approaches to this training have evolved over the years ranging from simple single channel tape playback of the targets audio signals to sophisticated and expensive target simulation hardware and software. Operators are required to perform sonar, command and control and other sensor analysis in a diverse set of conditions against a large category of targets while operating a variety of systems. Naval training experience has shown that training the operator to perform analysis in a tactical system environment using real world data and target signals is the most effective. The simulation of this environment can be accomplished by taking advantage of the latest commercial Digital Signal Processing (DSP), PC workstation, high resolution display and data storage and replay technology. PC based systems can be programmed to provide the various displays, display formats and Graphical User Interfaces (GUI) associated with the tactical systems currently deployed in the Fleet. Networking student workstations and an instructor workstation with a common data source DSP will provide a low cost, very flexible and realistic training environment.

PHASE I: Develop an innovative network centric training device concept based on the latest Commercial off the shelf (COTS) PC and DSP technology. The training device should provide a common hardware environment and software to support existing display formats and Operator Machine Interface (OMI) for existing submarine, surface and airborne sonar, other sensors and command and control functions.

PHASE II: Design and fabricate a prototype training device developed under Phase I of this effort. The device should be able to support at least 10 student workstations and 1 instructor station connected to a common data source DSP server.

PHASE III: Based upon a successful Phase II effort, develop and produce these training devices for the various US Navy ASW Training Centers to support basic and master level analysis training as well as pre-deployment training.

COMMERCIAL POTENTIAL: This research and development effort can apply to any training application where multiple students can be trained using high resolution video data display workstations connected to a common training data source over a network.

KEY WORDS: command & control function, other sensors, sonar; acoustic analysis; network based training; display formats; and Operator Machine Interface (OMI); Digital Signal Processing (DSP)

N99-109 TITLE: Enhancement in the Probability Detection of the Electronic Warfare Support (Es) Systems Against Modern Radars That Use Pulse Compression Techniques for Improved S/n Ratio

SCIENCE/TECHNOLOGY AREA: Electronic Warfare

OBJECTIVE: The objective of this effort is to develop an inexpensive and compact ES receiver to detect radars that use pulse compression or matched filtering technique to avoid unwanted compromise between range and resolution typically necessary in a traditional radar design.

DESCRIPTION: Modern radar systems, generally classified as Low Probability of Intercept (LPI) radars, use pulse compression techniques. These radars can frequently transmit at very low peak power levels since the radar receiver is matched to the modulation pattern of the transmitted signal. Matched filters used in such radars depend on the type of modulation on the transmitted pulse. Traditional and most commonly used modulation is Linear Frequency Modulation (LFM), though Non-Linear Frequency Modulation and Pseudo-Noise Modulations are also used. High processing gain resulting from matched filtering provides detection range advantage for these radars over the intercept receivers. The fact that the signal may be spread over a broad segment of the frequency spectrum and transmitted at low power makes it difficult for an unmatched Electronic Warfare Support receiver to detect the signal at any significant range or at all. This means that, depending on the radar cross section of the target platform and the gain of the receiving antenna, the radar may be capable of detecting the receiving platform at ranges greater than the receiver can detect the radar (resulting in a negative ES range margin). Since the purpose of an ES receiver is to provide warning of the presence of a radiating platform at ranges greater than that at which the radar can detect intercept platform, it may be necessary to employ new ES receiver types to ensure positive ES Arange margin over these radar systems. One example of a radar that utilizes a FMCW modulation technique is the AScout radar that is advertised for use as an undetectable coastal surveillance and tracking system.

PHASE I: Develop an Electronic Warfare Support receiving system design concept that will provide detection of low power FMCW and pulse compression radars at ranges greater than the detection range of these radars against platforms that have

moderate radar cross sections. The concept should develop approaches for countering the processing gain advantage of LPI systems over that traditionally provided by classical intercept receivers. Provide supporting analysis to demonstrate the detection range performance of the radar and the ES systems. The system concept must include the receiving antenna, internal system losses, receiver design and signal processing approach. Mechanically rotatable antennas may not be used and antenna dimensions must be limited to a cylindrical volume of five inches in diameter and five inches in height. Receiving and processing electronics must be mountable in Anineteen inch electronic cabinets and can not exceed a total volume of 2600 cubic inches. Detectability range margin analysis should consider radar cross sections of between 1 and 100 square meters and a range of radar effective radiated power levels.

PHASE II: Construct a laboratory prototype ES receiving system including an antenna and demonstrate key performance parameters in a laboratory test environment. Demonstrate how the equipment can be incorporated into a Naval ES system.

PHASE III: The successful system design will be integrated with existing naval ES Systems to provide enhanced LPI radar detection capability. Clearly identify and describe the expected transition of the product/process/service within the government as a result of the PHASE II in which the small business will participate under a PHASE III award.

COMMERCIAL POTENTIAL: The ES receiver has potential to be used on commercial ships to provide collision avoidance information.

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2. Beasley, P.D.L.: Stove, A.G.: Pilot B An Example of Advanced FMCW Techniques, Conference Paper, Record of the 1991 IEE Colloquium on AHigh Time-Bandwidth Product Waveforms in Radar and Sonar (Digest No. 093) p. 10/1-5

KEY WORDS: Electronic Warfare; Radar; Sensors; Modeling and Simulation; Electromagnetic; Antennas; Low Probability of Intercept.

N99-110 TITLE: Investigation of Commercial Off-The-Shelf (COTS) Radio Products for Submarine Communications Support

OBJECTIVE: Demonstration of the use of Commercial Off-The-Shelf (COTS) RF equipment for submarine applications

DESCRIPTION: New and enhanced Commercial Off-the-Shelf (COTS) RF and computer processing technologies have enabled the development of radio transceivers (one example is the Hughes AN/PSC-5 UHF SATCOM Terminal) that are compact, affordable, modular, and contain embedded Cryptographic (COMSEC), modems and Transmission Security (TRANSEC) capabilities. These products have been designed to be easy to operate and maintain, while providing total communications capability in one compact terminal. The objective of this Topic is to investigate the use of these new technologies to: a) replace existing legacy submarine communications equipment (such as the AN/WSC-3 UHF Transmitter/Receiver, the TD-1271 DAMA Unit and the external KG-84A COMSEC), which occupies considerable space and weight, requires considerable cabling, and is operator intensive equipment, and b) to introduce affordable new commercial telecommunications systems into the submarine using COTS transceiver products.

PHASE I: Develop a process to survey candidate technologies and products to satisfy the intent of the Topic for submarine communications systems, apply this process to a current submarine communications systems design, and develop a specific plan for a Phase 2 demonstration.

PHASE II: Design, develop and procure the necessary equipment and software to demonstrate the application of emerging COTS RF technology to reduce space, weight, power and to apply this technology to existing systems and to introduce new commercial telecommunications systems to submarines.

PHASE III: Integrate the results of the Phase 2 tasking into the NSSN Exterior Communications System and apply the processes and products towards the NSSN ECS Technology Assessment Process Plan.

COMMERCIAL POTENTIAL: The results of this effort are directly applicable to many facets of industry and Government. The smaller and inexpensive applications of the RF technology are obvious in every avenue of personal and industrial communications. The degree of difficulty and complexity increases as systems are developed that are a combination of military/military-like and pure commercial systems. The results of these efforts have direct application to airline communications systems, Federal Emergency

Management Agency, Customs, Drug Interdiction efforts and other DoD service applications. Some of the technologies applied to DoD systems may have direct application to commercial applications in areas of communications security and mobility.

KEY WORDS: Communications, Radio, Telecommunications, submarine

N99-111 TITLE: Improved Sonar Detection Displays and Interfaces

OBJECTIVE: Develop improved methods for displaying the varied types of submarine sonar information to improve the operator's ability to detect and classify new contact information while taking advantage of flexible display interfaces.

DESCRIPTION: New submarine sonar systems currently in development are using increasingly sophisticated signal processing to detect modern submarines. These sonar systems are using UNIX X-Windows controls and displays for operator interaction with the signal processing software. Advances have now been made in capabilities of three-dimensional display options that should be incorporated into submarine sonar systems. Given these improvements, the number of processing options and displays in the current systems can overwhelm the operator. With only a limited number of sonar operators on board ship, there is a significant need to distill the amount of information available and display it in a manner that optimizes the operator's ability to recognize new contact information and classify the information as to its source. Improvements in operator performance can also be achieved by optimizing the signal processing and display interactions.

PHASE I: Research and analyze the type of information currently processed and displayed in the sonar system. Research the current controls and displays for the purpose of optimizing repetitive operator actions and usability. Develop a conceptual design for improved displays and operator interfaces that maximize the operator's ability to detect new contacts.

PHASE II: Complete the detailed design of the improved displays and prototype the displays for further evaluation.

PHASE III: The improved displays will be incorporated into the new submarine sonar systems currently under development. Detailed documentation and display software would be developed to allow the displays to be integrated into these sonar systems.

COMMERCIAL POTENTIAL: The capability to distill large amounts of information and present to the system operator in a user-friendly, simplified manner has applications to many industries. Examples include medical imaging, undersea exploration, and the monitoring of complex systems.

KEY WORDS: Sonar; display; processing; interface; detection; controls; operator

N99-112 TITLE: Optimization of Very Low Frequency (VLF) Headset Audio

SCIENCE/TECHNOLOGY AREA: Sensors, Sonar systems

OBJECTIVE: The objective is to develop technology to optimize acoustic frequencies to correspond to human hearing frequencies. This would allow sonar operators to better detect transients and other display characteristics that show up on Hull Array and Towed Array Broadband and Narrowband displays. Although this focus is on VLF, medium and low frequency would be a secondary option.

DESCRIPTION: Up to now towed array and low frequency bow mounted sonar's have never idealized the frequency coverage for human ears. Previous system improvements such as the AN/BQR-7 had lower frequency coverage which provided for detection and tracking of large volumes of contacts because of the longer range made possible with the lower frequencies. however, this improved system was not popular with sonar operators because of the audio. When sonar operators got off other systems that covered frequencies more ideal to the human ear and immediately sat at the AN/BQR-7; they couldn't hear as well because of the difference in frequency ranges. If the operators allowed their hearing to adjust to these lower frequency ranges, they were able to experience the detection improvements inherent in the AN/BQR-7. The basis of this research topic is to translate frequencies and, if necessary, perform frequency multiplication to increase the bandwidth and present the new idealized bandwidth to correspond to human hearing frequency ranges most suitable to the operators. All sonar technicians take hearing exams routinely which shows the variability of

different persons hearing ranges. It would be optimal if the system could be calibrated to the individual since individuals hear differently and have hearing losses at different points on the spectrum. An innovative part of such a system would include a built-in hearing examination process which would calibrate the headset for each sonar operators specific needs. Subsequent re-calibrations could reoccur during the watch to help eliminate fatigue and strain associated with long periods of time on the sonar stack, especially during "battle stations" and "Fire Control Tracking Party" scenarios.

Training people to hear artificial frequency "aliases" would be the key to success of such a system. People would have to learn to think in terms of relative frequencies instead of discrete fixed frequencies. This topic would involve a sophisticated algorithm- driven higher frequency output that is tuned to each persons ear, at higher frequencies, most likely near 800 to 1000 hertz. Stereo and other advances in acoustics could also be used to enhance the oral detection process, which often enhances real time prosecution of lethal adversaries.

The initial concept would deal with experimenting with translating VLF signals of approximately 1 hertz to 150 hertz up to a frequency near 800 HZ and expanding the bandwidth to approximately 1000 Hz, thus providing frequency separation and better oral discrimination for the operators. Finite Infinite Response Filters (FIR) and Systolic Arrays would be implemented in the quest for self calibrating adaptive signal processing to re-map bandwidths for individuals.

PHASE I: Develop technology to optimize acoustic frequencies to correspond to human hearing frequencies. Although this focus is on VLF, medium and low frequency would be a secondary option. Perform simulations and experiments to demonstrate processes.

PHASE II: Develop a prototype to test dockside and at sea to prove suitability and applicability to acoustic oral detection capability and potential enhancements.

PHASE III: Turn over the technology to the private sector small businesses to manufacture and produce systems and hardware for the Navy.

COMMERCIAL POTENTIAL: Hearing aide companies and consumer electronics may benefit from this technology. Hearing impaired people may find new lease on life through frequency translation to bandwidths where they retain some element of hearing capability.

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2. Clay, C. S. and Medwin H., "Acoustical Oceanography: Principles and Applications," John Wiley & Sons, New York, 1977
3. New York Journal of Mathematics
4. American Mathematical Society
5. Society for Industrial and Applied Mathematics
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7. A. Papoulis, "Signal Analysis," McGraw-Hill, New York (1977)
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KEY WORDS: FFT, FIR, Adaptive Signal Processing, Systolic Arrays, Frequency Translation, Frequency Multiplication

N99-113 TITLE: <u>JAVA Applications for Naval Combat Systems</u>

OBJECTIVE: Improving software code re-use and portability in Naval combat systems.

DESCRIPTION: The majority of software code in use today by Naval combat systems is custom written, and specific to a single hardware platform and operating system. However, the current trend is toward Commercial, Off-the-Shelf (COTS) hardware/software, with periodic technology updates over the ship's life-cycle. This poses the possibility that substantial code re-writes may be required to be compatible with new hardware/software. This effort will assess and demonstrate the feasibility of using JAVA to improve software code re-use and portability in Naval combat systems. Significant life cycle cost savings can be realized through the elimination of non-recurring development costs by reusing previously developed software.

PHASE I: Identify candidate applications for using JAVA in an actual Naval combat system (e.g., New Attack Submarine). Develop a software specification to implement these candidate applications.

PHASE II: Develop the JAVA software applications and demonstrate their functionality and performance in a complex,

laboratory test setting (e.g., the NSSN Wide-Area Integration Test Facility).

PHASE III: Deploy and extend the JAVA software applications in support of a broad variety of Naval combat system development programs, e.g., NSSN, DD-21, LPD-17 and/or CVX.

COMMERCIAL POTENTIAL: Software code re-use and portability is an issue for a wide variety of military and commercial computer systems.

KEY WORDS: JAVA; combat systems; re-use; portability

N99-114 TITLE: Ultra-Fast Portable Metallic/Concrete Plate Cutting

SCIENCE/TECHNOLOGY AREA: Materials

OBJECTIVE: Develop man-portable technology and devices for ultra-fast cutting of metallic and concrete plates.

DESCRIPTION: Recent novel developments in cutting steel include combustion-synthesis-powered reactors that can project high thermal fluxes (ten megawatts per square centimeter). Concrete has been observed to melt and disintegrate when thermal lances burning at 4000#161#C are utilized. Both technologies have the disadvantages of being cumbersome and not man-portable because of heavy weight construction and umbilical-like fuel and oxidizer lines. Desired are devices that are small and lightweight enough to be used for salvage and rescue operations as well as underwater ship husbandry operations. Goals for salvage operations are a cutting rate of five feet per minute in a minimum of three-quarters inch plate and a maximum cutting depth of two inches.

PHASE I: Provide a feasibility study of the reactive breaching concept that includes novel cutting technologies and development of preliminary designs leading to ultra-fast cutting devices.

PHASE II: Develop these preliminary designs for lab-scale applied testing and evaluation useful for applications in the DoD and private sector. Deliver an experimental (bench-scale) working model to the Navy for evaluation as a cutting tool.

PHASE III: Develop a prototype of the selected cutting technology and device design. Fabricate and demonstrate the cutting device on concrete and steel that would have both military and private sector applications.

COMMERCIAL POTENTIAL: Salvage operations. Rescue operations in collapsed structures. Commercial and military demolition, breaching, and entry. Waterborne repair of ship's hulls and appendages.

REFERENCES:
1. J.E. Gatica and V. Hlavacek, "Laboratory for Ceramic and Reaction Engineering", Ceramic Bulletin Vol. 69, No. 8, 1990.
2. J. Mason and B. Blogg, "The Thermal Lance Technique for Cutting Hardened Concrete", C.S.S.A., Bull. 6, Aug. 1971.

KEY WORDS: Reactive breaching; reactive materials; high-speed cutting.

N99-115 TITLE: Corrosion Preventative Storage Systems

SCIENCE/TECHNOLOGY AREA: Materials, Processes and Structures

OBJECTIVE: Storage systems to protect equipment against corrosion from long-term exposure during open area storage.

DESCRIPTION: Open area temporary land-based stowage systems have not been adequate in protecting against corrosion and other environmental effects. Many staging facilities and storage locations do not use effective means of protecting items like propellers or Harpoon missile launchers from the elements. This has induced increased maintenance, required larger inventory to compensate for degraded equipment, and demands excessive lead times for items to be declared ready-for-use. Furthermore, shipboard items including the anchor windlass, torpedo tubes, 50 caliber machine gun mounts, chaff decoy launchers, and saluting batteries are exposed to the marine environment continuously with little protection or radar absorbing stealth capabilities. Maintaining a high state of readiness for these items requires many man-hours of upkeep removing rust and corrosion. The Navy currently does not have

an adequate temporary stowage system for topside shipboard equipment or propeller storage. Advances in synthetic fabrics and materials may provide new means for a temporary preservative storage capability that protects from the harsh marine environments and complement overall shipboard stealth technology.

PHASE I: Develop a storage system technology that completely protects shipboard torpedo tubes, 50 caliber machine gun mounts, chaff decoy launchers, saluting batteries, anchor windlass, and also propellers in temporary open area storage against the elements. Choose appropriate fabrics and materials that can be broken down immediately prior to shipboard equipment operation and requires a minimum amount of shipboard storage space.

PHASE II: Fabricate and test several systems onboard naval ships and at naval open area storage locations for a variety of factors including wind, rain, snow, ice, sand, ozone, aging, etc. to fully determine its effective range of performance. Perform internal humidity and atmospheric tests in several military environments, such as marine, desert, jungle and arctic, to determine its corrosion preventative capability potential. Storage systems for shipboard applications should also be constructed and tested for reduced radar cross section attributes. Compare findings to current methods of temporary storage.

PHASE III: Development of these products can benefit the Coast Guard, Army, Marines, and Air Force. Each service has many items stored in an open area that require constant upkeep and monitoring to insure equipment longevity. Any increase in shelf life will cut preservation and logistics costs, conserving military maintenance dollars.

COMMERCIAL POTENTIAL: Storage systems that protect against corrosion and other harmful effects have commercial applications in the commercial marine, cruise ship, off-shore oil platform, and manufacturing industries for use in protecting items from an aquatic environment.

KEY WORDS: Storage; Shelters; Synthetic Fabrics; Corrosion; RADAR Absorbing; Enclosed Environment

N99-116 TITLE: Precision Automatic Landing System

SCIENCE/TECHNOLOGY AREA: SensorsSensors, Electronics, and Battlespace Environment (DTAP-5)

OBJECTIVE: Design, construct and operate a ILS and precision automatic landing system for aircraft carriers that is at least as functionally equivalent to the currently proposed upgraded Automatic Carrier Landing System, the ACLS+. In addition, it must have the following enhancements: (1) uses technology that will not allow the identification of the ship as an aircraft carrier, (2) requires little or no modifications to the aircraft, (3) will not require topside ship board equipment with radar cross section greater than 1 square meter.

DESCRIPTION: The Navy plans to build a new class of aircraft carriers, presently designated as CVX, which will employ stealth technology. The present system used for ILS (Instrument Landing System) and automatic carrier landings does not easily lend itself to this requirement. A new,all service system, the Joint Precision Approach Landing System, JPALS, does meet this requirement. However, JPALS is GPS based and therefore depends on the presents and proper functioning of the GPS satellites. In a battlespace, these satellites may very well be disabled, thus causing this system to fail. The ACLS+ could operate in this battlespace environment, but as mentioned above, does not meet the desired signature requirements. What is sought is a secondary or back up system that meets all of the requirements. This system would support programs in PMS312 and PMS 378.

PHASE I: To develop and demonstrate, at least by detailed modeling, an innovative and practical ILS and automatic carrier landing system with the above capabilities.

PHASE II: Implement the innovation, which shall include the design and testing of a prototype system. Explore major cost and reliability issues associated with the technology in the context of both military and commercial viability.

PHASE III: Integrate the approach into emerging CVN77 and CVX architectures.

COMMERCIAL APPLICATION: JPALS is based on, and compatible with, the new commercial Free Flight Air Traffic Control system. Therefore the commercial community will have the same vulnerably to satellite failure as the military. Hence this proposed secondary system will provide a reliable back up for them as well.

REFERENCES:

1. JPALS IPT web site http://www.dtic.mil/c3i/c3ia/jpals.html.
2. CVX home page http://www.twoten.press.net/stories/98/03/18/headlines/
KEY WORDS: CVX; JPALS; ACLS; GPS; NAVAIR, ATC

N99-117 TITLE: Linear Motor Technology in the Vertical Plane.

SCIENCE/TECHNOLOGY AREA: Mechanics

OBJECTIVE: Advance linear motor technology for use in moving high-end loads in the vertical and horizontal planes, and transitioning between the planes.

DESCRIPTION: Conventional handling of cargo and weapons aboard ship requires multiple conveyances (forklift trucks, conveyors, elevators, dumbwaiters, etc.). Time and manpower are consumed transitioning loads between the various conveyances. An integrated system that could move material throughout the ship, both horizontally and vertically, is highly desirable. Such a system would require a third less manpower to operate and maintain than the multiple machines and multiple transitions currently used. The rapid deployment of weapons from supply ship to battle group and from magazine to aircraft, gun or assault vehicle would be enhanced. Linear motor technology is the method envisioned through which such a system could be realized. The development of this technology to enable a linear motor driven device to safely and efficiently move loads in the vertical plane and transition the load to and from the horizontal plane is the goal of this project.

PHASE I: Design and develop a linear motor driven device capable of loads up to 12,000 lbs, and employ multiple lifting platforms. Conduct and report design studies of existing and developmental linear motor technology and concepts and transition the horizontal based technology to vertical application. Explain in detail the selection of concepts, materials and components to be used in Phase II will be addressed.

PHASE II: Develop a working model, scaled in size to facilitate mounting on a ship motion simulator. The model will demonstrate the successful implementation of linear motor technology and concepts to simultaneously move multiple loads within a single trunk in both the vertical and horizontal planes and transition those loads between the two planes.

PHASE III: Develop a full scale model to be used as a land based test site through support of the Advanced Technology Demonstration or other DoD sponsored program.

COMMERCIAL POTENTIAL: Cableless elevator systems are envisioned for the 21st century high rise buildings. Conventional elevators in high rise buildings are restricted by the limitations associated with wire rope and the inefficient use of space and excessive waiting time associated with a single car system. Architects of super high rise buildings envision future building heights that far exceed the buildings that exist today. The limits of the conventional elevator are one of the major obstacles confronting these designers. A linear motor driven elevator system could allow multiple cars in a single hoistway.

REFERENCES: Hiroshi Kamaike, Toshiaki Ishii, Eiki Watanabe and Yoshitaka Matsukura, Mitsubishi Electric Corp., "A Ropeless Linear Drive Elevator", Elevator World Magazine, March 1991.

KEY WORDS: Aircraft Carriers, Cableless Elevator; Linear Motor; Material Handling; Linear Drive; Hoist

N99-118 TITLE: Innovative Solutions to Improve Combat Information Center Operations

SCIENCE/TECHNOLOGY AREA: Command, Control and Communications

OBJECTIVE: Reduce manpower requirements for Carrier Combat Information Center operations.

DESCRIPTION: Innovative techniques and methods are needed to reduce the manpower requirements for Combat Information Center (CIC) operations. CIC operations today, which involve collecting, processing, evaluating, displaying, and disseminating data, are manpower intensive. Planned enhancements to shipboard communication connectivity and networking within the battlegroup as well as enhanced ship to shore communications will enable high order of improvements to traditional CIC processes. Areas of

interest include, but not are limited to: intelligent integration of information from multiple sensors using extended methodologies for designating target location and identification; CIC process/procedural improvements that leverage advances in connectivity/networking and focus on increasing the effectiveness of CIC operations; leading edge technologies in the areas of optics and digital video processing; innovative approaches for enhancing visualization of realistic images of objects/targets within the simulated battlespace.

PHASE I: Develop an innovative technique, method, or concept of operations that improves existing Carrier CIC processes. Define the procedures/methods and equipment required for the process improvement; identify associated workload reduction; and develop an implementation strategy to demonstrate the innovation.

PHASE II: Demonstrate the new concept by developing a land-based prototype, maximizing use of advanced computer simulation technology to demonstrate the concept.

PHASE III: Demonstrate the new concept on a selected ship

COMMERCIAL POTENTIAL: This technology has potential application to commercial air traffic control and operations.

REFERENCES: CV/CVN Combat System Orientation & Management Guide, CSE (CV/CVN)-86-1 (Rev 2), September 1992

KEY WORDS: MANPOWER, INFORMATION, VISUALIZATION, CIC, CONNECTIVITY, NETWORKS

N99-119 TITLE: High Strength (120-150ksi yield) Corrosion Resistant Fastener Material

OBJECTIVE: Develop and certify a high strength corrosion resistant fastener material

DESCRIPTION: Multiple programs have identified a need for certified high strength (120-150ksi yield) corrosion resistant fastener materials. The currently certified material, K-monel, is unacceptable for critical applications due to problems with galvanic incompatibility with more noble alloys, hydrogen embrittlement, and slow strain rate embrittlement. Also, K-monel has only been certified for use at 90ksi. Recent tests data indicate that many of the coatings (such as cadmium, which is also hazardous) used on high strength steel fasteners breakdown in as little as two weeks in the marine environment. Standard fastener materials used in the commercial marine environment have not been certified to meet many of the additional requirements of the Navy, such as Impressed Current Cathodic Protection System, Shock, and Space and Weight limitation. The Navy has developed a Material Selection and a Fracture Toughness Review Process to ensure that materials selected will meet these demanding requirements. All new materials or existing materials used in new applications shall be selected in accordance with the procedures outlined in these documents.

PHASE I: Select a promising alloy or process to be used as the basis for developing the high strength fastener material. Candidate fastener materials must be compatible with the Titanium and Inconel alloy families, when used in a naval marine environment.

PHASE II: Develop and certify the process or alloy and conduct testing to verify that the process is reproducible. It is also desirable to minimize/optimize production costs such that they are approximately the same as for K-monel.

PHASE III: Develop appropriate specifications/documentation to make the system standard in the Fleet These fastener materials will be useful for Naval applications such as foundation bolting for heavy deck equipment (e.g. Boat Davits, Elevators), submarine hull integrity fasteners and other submarine applications where strength is paramount and space and weight are critical. These fastener materials would also be used as replacement for existing marginal designs, which currently require periodic monitoring to ensure satisfactory service.

COMMERCIAL POTENTIAL: These fastener materials will be useful to the commercial marine industry for applications such as off-shore oil rigs, submersibles, shipyard cranes, etc.

KEY WORDS: Fastener; Corrosion Resistant; 120-150ksi Yield; Material Certification

N99-120 TITLE: Water Scale Deposit Removal: Faster, Environmentally Safer and Lower Cost

SCIENCE TECHNOLOGY AREA: Materials, Processes and Structures

OBJECTIVE: To develop a low cost water scale, rust and lime removal chemical safe enough for daily shipboard maintenance that is non-hazardous, non-corrosive, non-toxic and is biodegradable. This chemical will increase equipment efficiency, decrease machinery cleaning man-hours, significantly reduce acid HAZMAT handling and save every ship maintenance dollars.

DESCRIPTION: Normal build-up of scale occurs in every water-cooled/heated piece of equipment over a period of time inevitably affecting many ship system efficiencies due to insulating the heat transfer flow. Hard scale deposits, consisting of calcium sulfate, calcium hydrate, calcium silicate, and iron oxide, inside water operated machinery, heat exchanger tubes and piping systems usually demand high pressure hydroblasting or even removing the equipment for shipyard chemical cleaning with hazardous acid. Safety and Naval operational constraints can prevent equipment removal or use of acid cleaning. A family of products is required that can be utilized far more effectively than removing equipment and subjecting it to an acid cleaning or hydroblasting. Chemicals should be made safe enough to hold in your hand and be capable of disposal in concentrated, unused form down regular sewer systems with a fresh water flush, minimizing costly HAZMAT disposal requirements. The chemicals must be compatible with metals found in shipboard water-cooled/heated systems and be used at nominal room temperatures. Required shipboard personnel protective equipment must be minimized and no hazardous vapors expended during use, allowing normal shipboard ventilation. The chemicals must breakdown the water scale, lime and rust buildup to a consistency no greater than coarse sand and eliminating clusters of solid particulate settling in machinery elbows or pipe bends that would restrict flow subsequent to the cleaning. After descaling, machinery efficiency should be at least 95% of the normal operating parameters.

PHASE I: Compile data, conduct tests and demonstrate the feasibility of an inexpensive chemical that is non-toxic, non-flammable, non-corrosive, non-hazardous and is biodegradable that will remove water scale (calcium sulfate, calcium hydrate, and calcium silicate), rust and lime buildup from shipboard machinery, to include: diesel engines, distilling plants, heat exchangers with associated piping systems, and seawater storage tanks. The chemical must be safe enough to use onboard a ship by trained sailors and be capable of disposal in unused form, devoid of neutralizing agents, following local regulations or discharged overboard while the ship is deployed. Also, develop a lightweight portable, chemical flushing unit to be used with the chemicals and stored in a minimal amount of space onboard a vessel.

PHASE II: Build two portable pump systems, create a test and evaluation plan, and test onboard selected Naval vessels on each coast. Develop a simple written process to clean and flush entire shipboard water-cooled/heated systems with chemical. Develop procedures and determine periodicity and cleaning requirements for each major piece of water cooled/heated equipment for individual ship classes. Requirements based on reduced efficiency due to internal blockage from scale buildup. Expand chemical cleaning development for use on entire CHT (Collection, Holding and Transfer) systems, radar water cooling systems and nuclear submarine water systems.

PHASE III: Use the data gathered to present at conferences and incorporate procedures into the U.S. Coast Guard vessels, USNS ships, Foreign Military Ship Sales Program, research vessels, Naval shore based boilers/power plants, and water cooling towers.

COMMERCIAL POTENTIAL: Commercial shipping also uses water to cool/heat equipment and requires descaling procedures. Using a 'safe acid' can enhance industry environmental compliance by allowing flushing down sewer systems. By using this chemical, many tens of thousands of dollars per commercial ship will be saved by not having downtime and dry-docking due to routine machinery scale buildup cleaning. Offshore oilrigs can also benefit by using the chemical regularly to clean water operated devices. Furthermore, the U.S. Army Corp of Engineers could benefit from this chemical's use by helping the organization remove and control Zebra mussel populations that infest river/ocean inlet piping for inland waterway utilities since the shells are calcium based and would erode similar to water scale.

KEY WORDS: acid; descaler; biodegradable; non-toxic; non-hazardous; non-corrosive

N99-121 TITLE: Sewage discharge pumps

OBJECTIVE: To provide a more reliable sewage pump that will also eliminate the need for having comminutors installed in the sewage system.

DESCRIPTION: Sewage pumps on present U. S. Navy ships are simply discharge pumps and are high maintenance drivers. The system requires communitors (also heavy maintenance burdens) to chop the solids into small enough pieces to pass through the pumps. A reliable pump is needed that chops the solids and discharges the fluid overboard or to the existing deck risers to offload the fluid.

PHASE I: Research and define requirements for a more reliable/maintainable CHT pump. The new pump must be able to chop solids and pump the waste off the ship without the need of a communitor.

PHASE II: Design and fabricate a prototype pump onboard a selected ship for evaluation. Develop a test plan for evaluation of the prototype pump, including pass/fail criteria.

PHASE III: Develop different size pumps to accommodate most if not all pump requirements for U. S. Navy ships. This technology should be developed to meet the capacity/discharge requirements of all PEO EXW ship classes. The same technology would then be available to other PEO's ship classes and utilized throughout the NAVY. The design would then be available to any NAVSEA/PEO Program Manager or Type Commander to pay for the construction of pumps needed to fulfill the discharge capacities for their ships.

COMMERCIAL POTENTIAL: This pump can be utilized in U. S. Coast Guard, MSC and commercial ships for disposal of sewage.

KEY WORDS: Sewage pump; macerator; sewage ejection pump

N99-122 TITLE: Total Ship Training Concept

SCIENCE TECHNOLOGY AREA: Training

OBJECTIVE: Develop innovative concepts and techniques for integrating legacy and new development shipboard trainers and training models in a crew/embarked Marines mission training environment

DESCRIPTION: Recent developments in Navy shipboard training programs such as Battle Force Tactical Trainer (BFTT) have revolutionized the manner in which we train our crews in combat systems employment. BFTT utilizes advanced distributed modeling and simulation techniques in concert with a cognitive learning model to optimize team performance. Other shipboard training systems and trainers for embarked Marines are utilized in a stovepipe fashion to train their operators in systems such as Damage Control, Air Traffic Control, Combat Vehicles and Machinery/Ship Control. In the real world the systems and operators that these trainers represent are tightly coupled and highly dependent on each other's condition and actions as a result of operational decisions and battle damage. Total ship/force performance can be greatly improved by developing innovative techniques for netting these disparate training systems together in a team-training environment.

PHASE I: Develop innovative Training concept of operations, provide an architecture for interactive utilization of selected trainers and identify likely shipboard and Fleet Marine Force training system candidates to receive this tehcnology.

PHASE II: Develop a prototype Total Ship Trainer demonstrating the openness of the chosen architecture and the training value added for ships company and embarked Marines of the interaction between the trainees.

PHASE III: Build upon the architecture developed and demonstrated in PHASE I & II to develop and produce a Total Ship Training environment for New ship classes and apply the architecture to existing ships as a back-fit program.

COMMERCIAL POTENTIAL: Many industries rely upon stovepipe trainers to hone the skills of individuals operating within limited functional responsibilities. Commercial power plants, Air Traffic Control, large manufacturing plants, etc. can benefit from this technology by training the entire work force in a netted/distributed fashion.

KEY WORDS: Team Training; distributed simulation; cognitive learning; open systems; reusable software; trainers

N99-123 TITLE: Corrosion Preventative Methods for Structural Steels

SCIENCE TECHNOLOGY AREA: Materials, Processes and Structures

OBJECTIVE: Develop and demonstrate new methods of corrosion prevention for structural materials allowing the metal to remain in open outside storage areas minimizing any corrosion or oxidation.

DESCRIPTION: Corrosion has been an extraordinary problem for the Navy as well as industry for many years. Building a Naval ship requires several years of construction with months of lead-time for structural components. Many of these components may lay for weeks in open areas exposed to the elements and begin to rust and corrode before final fabrication and installation aboard the vessel. Removal of corrosion and reconditioning the metal adds many man-hours of work and increases construction cost. Recent developments in metallurgy and related commercialization efforts have opened new possibilities to combat corrosion in structural materials that could allow the metal to remain free of corrosion from initial metal manufacturing through final fabrication, assembly and painting.

PHASE I: Develop a new metallurgical process for corrosion prevention of structural steels. Analyze the results to preliminarily determine the corrosion preventative potential of this new process and demonstrate the feasibility to use this process on shipboard metals.

PHASE II: Apply the corrosion inhibiting process to low/high carbon, mild, ordinary-strength, HY-80, HY-100, HY-130, high-strength low-alloy (HSLA) steels and other structural alloyed steels. Test for a variety of factors including weldability, fatigue resistance, ease of use in construction, and abrasion resistance to determine the general applicability for such a process to be used for structural metals. Evaluate the process to determine use in piping systems, and seawater storage tanks. Perform Salt Spray and other corrosion tests on these metals treated in this new process. Evaluation to include a shipboard phase and written report of findings. Investigate design of a portable corrosion inhibiting application unit that can treat welds and other untreated metal added that are a result of repairs. Evaluate the process for use on weapon mounting systems, LCAC aluminum structures and submarine manufacturing metals.

PHASE III: Shipyards and Naval facilities will participate with the small business concept developer to investigate transition of the metallurgical process technology into a large scale production processing facility constructed in the vicinity of major steel manufacturer's to minimize costs associated with transportation of metal and relieve deterioration due to open area storage.

COMMERCIAL POTENTIAL: The process developed under this topic has performance potential in common with corrosion inhibiting requirements of the Coast Guard, Army, Marines, Air Force, commercial ocean freighters, and cruise ship fleets. The field of corrosion prevention is also broad enough to apply to many industries including: automobile, appliance, aerospace, farm implements, oil, and many others.

REFERENCES:

1. American Bureau of Shipping, Rules for Building and Classing Steel Vessels, New York, 1978.
2. Fink, F.W., and W.K. Boyd, The Corrosion of Metals in Marine Environments, Defense of Metals Information Center, Columbus, Ohio, 1970.
3. LaQue, F.L., Marine Corrosion Causes and Prevention, John Wiley & Sons, New York, 1975.

KEY WORDS: corrosion; metallurgy; metals; metallurgical process; structural materials; rust

N99-124 TITLE: Microwave Technology Treatment for Sewage System

SCIENCE/TECHNOLOGY AREA: Environmental Science

OBJECTIVE: To provide a treatment system for sewage and gray water

DESCRIPTION: Recent developments in industry have proven that sewage and gray water can environmentally be handled with microwave technology. This technology can and should be adapted to shipboard use. Presently, ship's collect, hold and then transfer off the ship all their sewage and gray water without treatment. In port the ships discharge the waste to pierside connections, at sea

they discharge sewage overboard and gray water from most locations drains overboard.

PHASE I: Design an applicable waste treatment system to handle sewage and gray water waste streams to eliminate sludge and produce an effluent that is environmentally safe to discharge overboard.

PHASE II: Build and install on a ship the new microwave treatment facility to handle all the sewage and gray water streams in an environmentally safe manner.

PHASE III: Develop installation guidance for shipboard installations for all classes of U.S. Navy ships. Develop strategy for the expansion of this technology into the Solid waste, Medical waste, hazardous waste and any other applicable waste shipboard streams.

COMMERCIAL POTENTIAL: This system can be utilized in residential and commercial markets.

KEY WORDS: Microwave; Extraction; Microwave incineration; membrane technology

N99-125 TITLE: Advanced Verification and Validation Techniques

SCIENCE TECHNOLOGY AREA: Modeling and Simulation

OBJECTIVE: Develop verification and validation (V&V) techniques applicable to complex models and simulation systems.

DESCRIPTION: The improved availability of processing power has brought a revolution to modeling and simulation. It is now possible to employ extremely complex dynamic algorithms in the simulation of reality. These algorithms typically involve interdependence of several variables and offer better fidelity than simple algorithms. However, our ability to simulate complex behaviors and scenarios has outpaced our ability to clearly define the bounds of conditions under which these simulations accurately reflect the real world. New methods are required for determining and describing the degree to which intricate simulations emulate reality.

PHASE I: Define metrics which identify critical aspects which models or simulation must address to provide a sufficient representation of reality for specific purposes. Identify potential approaches for quantifying model or simulation performance against such metrics.

PHASE II: Develop and document the quantifying techniques identified in PHASE I. Apply these techniques to at least two behavioral models and/or large simulation systems to demonstrate their utility.

PHASE III DUAL USE APPLICATIONS: Once developed and tested, these techniques will be employed in establishing and defining the validity of all new simulations. Beyond application to modeling and simulation, methods that define the validity of multi-variable processes have widespread DoD applications. The effectiveness of Tactical Decision Aids that must consider several interdependent variables could, for example, be evaluated. The ability of a combat direction system to produce desired results under extreme or unusual conditions could also be defined using the techniques developed under this effort.

COMMERCIAL POTENTIAL: Simulated manufacturing is becoming more prevalent in the commercial world. The models used in this context continue to become more detailed and complex considering the cost and schedule interdependencies of such things as work flow, parts ordering and delivery, retooling, and staffing level per shift. The accuracy and limits of these models must be verified if sound business decisions are to be made. Additional Commercial applications are possible in the measurement of effectiveness of a national distribution system, airline utilization of aircraft, or a communications network switching system.

REFERENCES:
1.) Department of Defense Policy Instruction 5000.61, November 1996
2.) Department of Defense Verification, Validation, and Accreditation Recommended Practices Guide, November 1996

KEYWORDS: Verification; validation; modeling; simulation; performance; metrics; multivariable analysis

N99-126 TITLE: Modeling and Simulation (M&S) Environment Server for Distributed/Embedded Environment Representation

SCIENCE TECHNOLOGY AREA: Modeling and Simulation

OBJECTIVE: The objective of this effort is to develop an environment data and effects server which can serve out a consistent environment representation when implemented as a distributed application or as embedded components.

DESCRIPTION: There is a need for all the components of a simulation that use parameters describing the natural environment (weather, sea state, etc.) to receive environment data and calculate environment effects consistently. Existing approaches have focused on a centralized software server that provides all the environment parameters for simulation components. However, many distributed simulation implementations require the capability to calculate environment effects locally, to relieve bandwidth congestion or satisfy security concerns. In addition simulations which use legacy models often have environment calculation routines embedded within the simulation.

PHASE I: The contractor will develop a design for a synthetic environment data and effects server capable of operating as a distributed implementation, and capable of controlling embedded environment calculation routines.

PHASE II: The contractor will develop a prototype capability and demonstrate the prototype in conjunction with a related demonstration of an M&S system.

PHASE III: The contractor will mature the prototype system and develop supporting documentation that describes system installation, configuration and operating procedures.

COMMERCIAL POTENTIAL: A software application of this type could be sold commercially to developers of M&S systems as a helper application or component.

KEY WORDS: M&S; environment; server; prototype; distributed; embedded

N99-127 TITLE: Object Resolution Mapping

SCIENCE TECHNOLOGY AREA: Modeling and Simulation

OBJECTIVE: Develop schemes for the mapping of objects from a simulation at one resolution to a simulation at a different resolution.

DESCRIPTION: Within the framework of the Defense Modeling and Simulation Office's High Level Architecture (HLA), data is exchanged between simulations in the form of objects. To efficiently represent large scale operations in simulations and yet retain the ability to investigate portions of the battle space in detail, it will be necessary for simulations at fundamentally different levels of resolution to operate with each other. In order to do this, there must be consistent and verifiable methods of mapping the information within the simulation at one level of resolution to the information required by the simulation at a different level of resolution.

PHASE I: Identify possible schema for the correlation of data of different levels of detail between simulations. Estimate the feasibility of employing each scheme in simulation exercises. Design implementations of the most promising of these schemes.

PHASE II: Produce a limited implementation of the designs produced in the first phase. Demonstrate the viability of the designs by facilitating the moderate interoperability of two simulations of different levels of detail.

PHASE III: The new generation of communication systems will be object based. Effective operation of multiple systems within this architecture requires that these systems share a common and unambiguous interpretation of each object. Such a shared interpretation is unlikely for communication systems independently developed by different services, different contractors, and for different purposes. To ensure compatibility between systems, an object mapping scheme will be required.

COMMERCIAL POTENTIAL: Many commercial systems use the construct of objects for information transfer. The object mapping schemes developed by this effort could allow for systems using disparate object definitions to communicate with each other.

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1.) Department of Defense Modeling And Simulation (M&S) Data Administration Strategic Plan (DASP), April 1996 at Internet http://www.dmso.mil

2.) Department of Defense Modeling and Simulation (M&S) Master plan, October 1995 at Internet http://www.dmso.mil

3.) Information on the High Level Architecture and modeling and simulation data standards can be found at the Defense Modeling and Simulation Office web page at http://www.dmso.mil

KEYWORDS: Resolution; data objects; HLA; correlation; simulation.

N99-128 TITLE: Battle Group Measures for Assessing Training and Readiness

SCIENCE TECHNOLOGY AREA: Modeling and Simulation

OBJECTIVE: Develop a technical framework to link Navy Mission Essential tasks to tactical training curriculum for assessing training effectiveness.

DESCRIPTION: Battle Group training involves exposure to the complex set of options of command and control that optimize the fighting capability of hardware/software systems, people and tactics needed to execute mission essential tasks. The mission essential tasks as specified in the Universal Navy Task Lists (UNTLs) identify those tasks to be performed and the conditions under which they must be performed. Training the fleet involves both instructing "What to do" and "How to do it" for those essential tasks, and then the actually doing of those tasks in live training exercises. The UNTLs do not reflect "who" is to do the task nor "how" the task is to be performed. "Who" does the task is generally defined in a concept of operations (CONOPS) and the "how" the task is conducted is contained in the myriad of tactics and doctrine that can be chosen by a commander. The measures of performance listed in the UNTLs are outcome based, and therefore are not sensitive to tactics or who performs the task. For training to be effective, the task must be understood, the proper tactic chosen and the doer must properly perform the task and tactic. The selection of a course of action by a commander is typically based on his/her previous discovery and familiarity in decision making, which may not be the optimal solution for the given situation. Consequently exposure to all tactical situations possible during the training experience will expand the range of response and will lead to the chance of a more optimized tactical choice to counter the tactical behavior of the opposing forces.

Consequently, for Fleet training to be effective there must be a realization of the wrong course of action and a realization of the conditions for selecting the right course of action. Consequences of right and wrong courses of actions must be fed back to the trainee in rapid after action reporting to impart full realization of decisions made and actions taken.

Achieving the desired result from Battle Group command and decision training is only possible if the Navy Mission Essential Tasks are linked to the tactic/doctrine being employed and that in turn is linked to the proper procedure for the expected environmental conditions. The tactics chosen are the prerogative of a commander who assesses the battle situation for the conditions of the tactic. There may be several tactics that could apply, but knowing which to choose and command as the optimal one at the right time, should be significant part of training. Tactics are accompanied by procedures that must be implemented for an effective tactic. The environmental conditions under which the task is to be executed, such as at night, at -10 degrees Fahrenheit with a 35 knot south wind, and sea state 3 in moderate rain is critical to understanding applying the proper tactic to the task. Consequently, the minimum essential data needed to measure performance and effectiveness of the training must include the task, the doer(s) of the task, the conditions of the task, and the tactics and procedures chosen.

No framework exists or cognitive method or training tool or aid exists today that links tactics and conditions to the Navy Mission Essential Task Lists (NMETLs) or Universal Navy Task Lists (UNTLS) for training use. The training methods today focus on understanding processes and do not incorporate battle group measures of performance/effectiveness outcomes. The published UNTLs measures are predominately outcome-based measures, but do not incorporate the doer and the tactics with the conditions. Consequently these measures by themselves have little relevance for assessing whether a minimum standard of proficiency in executing the specific task list was achieved.

PHASE I. Develop an appropriate new method for linking the UNTLS with tactics, conditions and procedures into a tactical training tool or aid that can be integrated into the Navy's JSIMS Maritime and BFTT programs. The performance of a trainee must be measurable. Therefore, this phase will propose associated measures of performance and effectiveness and asociated data collection sources in order to quantify the value of the training aid. Example performance measures of interest include the gain in

performance from taining applications that integrate use of tactics into mission tasking at varying levels of war.

PHASE II will focus on proto-typing the technical framework for one warfare area from PHASE I into a training aid. This phase will also demonstrate the functioning of the tool in a selected set of training events utilizing the performance measures proposed in PHASE I. This phase will focus on the application in a real training event, collecting data to produce the performance measures and providing feedback of the measures to the trainee for comparative analysis of this approach toward improving training over the current training approach.

PHASE III. This phase will result in the integration and implementation of the training assessment technical framework and after action review techniques within BFTT and JSIMS Maritime programs. Included will be defining and integrating of requisite data collection and data processing methods, and the creation of rapid feedback displays of the evaluative measures within the training environment of BFTT and JSIMS

COMMERCIAL POTENTIAL. This innovative research technology will have the potential for the commercial market to provide improved training approaches to all aspects of civil, government, and military planning, crisis management and training.

KEY WORDS: Technical framework, training, performance assessment,

N99-129 TITLE: QoS Optimization Tool for the Internet Protocol (IP) Based Integrated Services Internet

SCIENCE/TECHNOLOGY AREA: Command, Control and Communications

OBJECTIVE: To develop a QoS optimization tool, including a set of traffic control functions and realistic delay bound scheme, to optimize bandwidth allocation such that network utilization can be enhanced by as much as 50% while maintaining Quality-of-Service (QoS) commitment in the IP-based Internet.

DESCRIPTION: The traffic demand on the IP-based Internet is continually increasing. Such demand includes two fundamental challenges: greater bandwidth and higher QoS commitments. They often conflict with each other. The Internet Engineering Task Force (IETF) has developed a suite of standards to provide QoS transport over IP-based networks. These standards fall under the umbrella of Integrated Services (Int-Serv), which is particularly well suited to emerging real-time, multimedia, and multicasting applications.

At the heart of Int-Serv, packet delay is the key requirement to providing the desired QoS objectives. Usually, it uses a conservative bandwidth allocation approach, which is based on theoretical worst-case traffic behavior. As such, the end-to-end delay bound is hard bound or set at the maximum and unchangeable limits. In this approach, the utilization of bandwidth is quite low, since the actual delay is often much less. How to maximize the entire network utilization while keeping QoS commitments in the Internet is an open and important question

The solution may include the investigation and development of new algorithms or methodologies that can determine the realistic delay bound instead of the hard delay bound by considering accurate traffic models and statistic multiplexing. The realistic delay bound and aggregate traffic conditions should be dynamically and accurately reflected in assessment of the existing traffic load and bandwidth allocation for upcoming traffic requests.

To achieve QoS goals, critical traffic control functions shall be reviewed and proposed, such as packet scheduling, packet dropping, packet classification, and admission control. Altogether, the outcome will be a QoS optimization tool, which will result in a higher network utilization rate by as much as 50% while satisfying service objectives

PHASE I: Develop a preliminary working prototype of IP QoS optimization tool, including traffic control functions with a realistic end-to-end delay bound scheme, to prove the feasibility of optimizing both bandwidth utilization and QoS. Complete a trade-off analysis between vendor-implemented delay bound schemes and IP QoS commitments, and continue toward Phase II.

PHASE II: Develop a complete tool, incorporating IP traffic control functions and the end-to-end delay bound scheme, that can optimize the above network parameters and maximize the IP network usage and QoS delivery. Prototype the proposed solution on the simulation platform that can meet the stated objectives and integrate it with a Navy-selected network-vendor's platform.

PHASE III: Integrate the software products with an actual IP-based network in the Navy shipboard environment.

COMMERCIAL POTENTIAL: Many industrial/commercial activities would use, and benefit from the use of, this innovative

technology. Examples are organizations that require real time, multimedia and multicasting applications to be transported over the Internet with a QoS requirement for bandwidth and IP services. The proposed solution will conform to the open Int-Serv structure. Hence, besides military applications, it will have dual use applications in the commercial sector. The proposed solution can also be deployed as a key component of the Internet Engineering Task Force Int-Serv QoS package for the upcoming Internet upgrade.

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1. RFC 1633, AIntegrated Services in the Internet Architecture: An Overview, July, 1994.
2. RFC 2205, AResource ReSerVation Protocol (RSVP) Version 1 Function Specification, September 1997.
3. RFC 2212, ASpecification of Guaranteed Quality of Service, September 1997.
4. RFC 2211, ASpecification of the Controlled-Load Network Element Service, September 1997.
5. RFC 2208, AResource ReSerVation Protocol (RSVP) Version 1 Applicability Statement Some Guidelines on Deployment, September 1997.

KEY WORDS: Network Utilization, QoS, IP, Internet, Integrated Service, Traffic Model

N99-130 TITLE: Navy Command System: A Quality of Service (QoS) Management Tool Over Internet Protocol (IP)-Based Networks

OBJECTIVE: Investigate the network characteristics of carrying voice, video, and multi-media applications over both wire and wireless IP networks for the purpose of developing a set of IP quality-of-service (QoS) management tools to facilitate end-to-end QoS provisioning.

DESCRIPTION: A critical issue in today's networking environment is how communication infrastructures (both wire and wireless) interoperate with TCP/IP protocols to provide a guaranteed, end-to-end Quality of Service (QoS) delivery. There is no standard approach for configuring QoS parameters; there are only vendor-specific implementations.

Guaranteed QoS is being recognized as the missing piece in the evolution of QoS-based service offerings in the Internet. Routing developed for today's Internet is based on IP protocols and typically supports only one class of service to users, called "Best Effort" routing. Best effort routing uses only the destination address to decide the routes, which is not a good way if multimedia traffic is to be routed. Multimedia traffic requires more strict specifications for their routes (e.g. delay and jitter).

To improve network performance and guarantee QoS delivery with IP protocols over both wired and wireless network infrastructures, it is proposed that an interoperability study of existing and emerging technologies be undertaken, using both real and simulated network traffic in a heterogeneous vendor environment. The results of this study will be used to develop a set of IP QoS management tools. The outcome of this study and the resultant management tools will assist the Navy and network service providers in configuring their networks to achieve quality of service guarantees while maximizing network utilization.

PHASE I: Phase I will be divided into two sub-phase efforts. First, a technical comparison of IP QoS standards published by the Internet Engineering Task Force (IETF) and International Telecommunications Union (ITU) with the IP QoS implementations of the major equipment vendors will be performed to analyze and document equipment standards conformance. Second, development of a preliminary working prototype of an algorithm (software) that will map IP QoS parameters into HP OpenView (a widely used Navy network management system) to prove the feasibility of managing IP QoS standards from a network management system platform and continue toward Phase II.

PHASE II: Develop management and provisioning characteristics and guidelines for IP QoS parameters in both wired and wireless environments. Develop and demonstrate a prototype of an IP QoS planning and management tool that can assist network designers in configuring more efficiently networks that consists of heterogeneous vendor equipment.

PHASE III: Test the QoS management tools in Navy shipboard environments on wire and wireless communication networks. Document the results of improvements in networks reconfigured using these tools.

COMMERCIAL POTENTIAL: Many industrial/commercial activities would use, and benefit from the use of, this innovative technology. Since IP QoS Management tools can provide QoS guarantees and network performance improvements in a heterogeneous environment, this will be of considerable benefit to manufacturers of switches and routers for increased thru-put. Commercial Internet Service Providers will be among the first to benefit from improved network performance by having available to them IP QoS management tools that insure quality transmissions of multi-media traffic.

KEYWORDS: IP Protocols, Quality of Service (QoS) parameters, network performance improvements

N99-131 TITLE: Simulation Based Acquisition Environment Development

SCIENCE/TECHNOLOGY AREA: Computer Science & Technology

OBJECTIVE: To research, design, prototype and demonstrate a collaborative, distributed data, modeling and simulation application environment capable of supporting the activities associated with complex systems acquisition.

DESCRIPTION: Systems engineers, designers, acquisition managers, functional area experts, and business managers face an unprecedented challenge in the capture, analysis and synthesis of information required to evolve systems from concept definition through development, deployment, and upgrade to retirement. Adding to this challenge, designers of these system products must meet the broad mission objectives within stringent budgetary constraints while satisfying performance requirements and schedule.

Simulation Based Acquisition (SBA) is a new acquisition paradigm which holds the promise of enabling the management of the product and process complexity inherent in major system acquisitions. SBA is embodied by three principals tenants: a virtually-integrated data, modeling and simulation environment; an iterative acquisition process which takes advantage of the that environment; and an evolved culture where enterprise-wide cooperation and integration is facilitated by the digital environment. SBA, and the underlying notion of an integrated enterprise digital acquisition environment is a key enabler to producing more expedient, higher quality Naval systems at unprecedented cost savings. This topic seeks to pursue a three-phased research program which will define, design and integrate the acquisition and engineering data objects and associated application objects within an SBA environment; define a data object model template (OMT) and a Object Database Connectivity (ODBC) interface for modeling and simulation applications; design and specify an Object Request Broker (ORB) communication architecture; specify an ORB Interface Definition Language (IDL) and services for an internet client/server computer and database management system communications infra-structure needed by SBA. Based upon the OMT, ODBC, ORB and IDL specifications, prototype and demonstrate a representative subset of acquisition, engineering, functional and business databases, models and simulation applications in an integrated SBA environment.

PHASE I: Research and develop a design specification for the essential OMT, ODBC, ORB and IDL infra-structure required to create an integrated information environment for SBA, using existent models and simulation applications.

PHASE II: Develop a functionally representative SBA environment prototype supporting the broad range of acquisition, engineering, functional and business processes.

PHASE III: Demonstrate, extend and deploy the SBA environment infra-structure in support of a broad variety of Naval and Defense acquisition programs, and commercial industry systems/products.

COMMERCIAL POTENTIAL: Trends in recent business enterprise management of complex system/product development indicate the growing need to integrate engineering design and development, manufacturing and production, and financial information, models and simulations in a seamless integrated data and applications environment. For example, the rise of Enterprise Resource Planning (ERP) products such as those from Iona, Baan, SAP, and PeopleSoft demonstrate that complex management structures require an advanced integrating infrastructure to support increased competitiveness and decreased time-to-market for such complex products as aircraft, communication systems, shipbuilding, vehicles, and space systems. A robust, extensible engineering data, modeling and simulation infrastructure capable of providing support to the engineering, functional and business management activities associated with developing such complex systems offers the potential to revolutionize the systems engineering tool market.

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Simulation Based Acquisition, An Effective, Affordable Mechanism for Fielding Complex Technologies. Sanders, Dr. Patricia, Director, Defense Test, System Engineering and Evaluation.
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KEY WORDS: simulation-based acquisition; modeling & simulation; acquisition; complex systems; systems engineering; affordability

N99-132 TITLE: Security Mode Verification for Untrusted Workstations

SCIENCE/TECHNOLOGY AREA: Command, Control and Communications

OBJECTIVE: Develop and demonstrate a method of externally and independently verifying that a group of networked workstations with embedded encryption and untrusted operating systems are configured properly.

DESCRIPTION: Future Navy ships will make use of workstations with untrusted operating systems, e.g., WindowsNT7 or Windows957, that handle classified information. The information will be protected via workstation-embedded encryption. However, due to the untrusted nature of the operating system, there is nothing to prevent the careless or malicious operator from reconfiguring the workstation so as to use an incorrect encryption algorithm, or to bypass encryption altogether. What is needed is some method of externally detecting that a workstation's security mode has been changed from a desired baseline configuration. The verification method should be implemented by some technique that cannot be bypassed by the workstation operator. The technique should support multiple security configurations on different workstations and the security configuration must be able to be verified even if it dynamically migrates as applications migrate from one workstation to another workstation.

The R&D technologies that might be exploited to meet the requirements of this topic include (a) Asmart agents residing on workstations that are capable of detecting changes in the security structure of the workstation, (b) special server software that can poll workstations and compare their security structure with a desired, baseline structure, and (c) high-performance network technology that can support rapid security client-server exchanges at a pace needed to keep up with dynamic application migration.

PHASE I: Develop the architecture of the security mode verification scheme and show (via paper analysis) that it cannot by subverted by the workstation operator. Develop an initial prototype of the architecture to establish its feasibility. Test the prototype and identify the improvements that will be needed during Phase II.

PHASE II: Extend the Phase I prototype to create a robust Phase II prototype demonstration model that incorporates the improvements needed from the Phase I baseline. Determine the performance of the innovation in terms of ease of setup and management by the security administrator. Explore major cost and reliability issues associated with the technology in the context of commercial viability.

PHASE III: Productize the innovation for use in military and industrial/commercial applications. Typical military applications include the DD-21 ship class and any ship being upgraded with a multilevel security network and workstations with an untrusted operating system .

COMMERCIAL POTENTIAL: Many industrial/commercial activities would use, and benefit from the use of, this innovation. Examples are organizations that require high security but do not use trusted operating systems for cost or ease-of-use reasons, e.g., organizations that perform electronic funds transfer, organizations that have closely-held trade secrets, etc.

KEY WORDS: security; encryption; untrusted-workstations; configuration-verification; untrusted-operating-systems; security-monitoring

N99-133 TITLE: Performance Interoperability in Internet Protocol/Asynchronous Transfer Mode (IP/ATM) Networks

SCIENCE/TECHNOLOGY AREA Command, Control and Communications

OBJECTIVE: Investigate the performance interoperability in IP/ATM networks with heterogeneous vendors' products. Develop a simulation tool based on OPNET to facilitate seamless interoperability of the networks such that end-to-end network performance will not be downgraded and can be optimized in multi-vendor environment.

DESCRIPTION: Different network equipment vendors provide proprietary networking solutions to local area networks (LANs), wide area networks (WANs), asynchronous transfer mode (ATM) networks, synchronous optical networks (SONETs), and to the Internet. How their products (such as switches, routers, bridges) can be made to cooperate to provide end-to-end quality-of-service (QoS) guarantees becomes a critical issue in today's shipboard networking environment.

As an example, vendors like Cisco, Bay Network, and Cabletron have proposed and implemented various scheduling policies, such as weighted fair queuing (WFQ), earliest due date (EDD), and strict priority queuing. Combined with various buffer management schemes, such as random early detection (RED), weighted RED (WRED), early packet discard (EPD), partial packet discard (PPD), dynamic threshold, and longest queue push-out, they provide an integrated service solution with different QoS requirements (delay-sensitive, loss-sensitive, etc.). Deploying multi-vendor equipment in Navy shipboard networks with different combinations of these QoS implementation schemes can have distinct impacts on network performance and utilization.

An investigation is needed to examine how vendor implementation of IP QoS can interoperate with one another. A determination needs to be made as to whether the network performance will be downgraded in a multi-vendor network environment as opposed to a single vendor network. Also a determination needs to be made as to how can we optimize the performance of multi-vendor networks. A complete set of OPNET simulation models shall be developed based on the framework of the performance interoperability study to help the Navy or network service providers configure their networks to achieve network performance optimization. The simulation tool shall include models for equipment, protocols and traffic source types, which are used by the Navy. The model development shall conform to the standards of Network Warfare Simulation (NETWARS).

PHASE I: Identify problems and issues regarding the QoS implementation in heterogeneous IP/ATM networks. Develop a preliminary working prototype of interoperability-optimization algorithms to prove the feasibility of using these algorithms to configure a heterogeneous network and continue toward Phase II.

PHASE II: Develop interoperability-optimization algorithms or guidelines for heterogeneous network configuration. Prototype a simulation tool incorporating interoperability-optimization algorithms, that can assist network designers in configuring their networks in a heterogeneous vendor-equipment environment.

PHASE III: Demonstrate, extend and deploy the simulation tool in the entire NETWARS environment and commercial OPNET environment to enhance the network interoperability performance in the broad scope of military networks and the commercial industrial networks.

COMMERCIAL POTENTIAL: Many industrial/commercial activities would use, and benefit from the use of, this innovative technology. Many vendors who manufacture ATM equipment for LANs and WANs do not cooperate to provide a capability for Quality of Service when multiple vendors equipment are used in the same installation/environment in many cases today. This is a critical issue to the Navy, since we use all COTS equipment within a mixed vendor environment of installed equipment for our shipboard networks. For example, if this set of simulation tools were available today, we could install network components together from multiple vendors and be able to operate our network with a maximum QoS and efficiency. The first to benefit from this technology besides the military, would be the network equipment manufacturers being able to for the first time provide a really true QoS Capability for ATM network equipment in mixed vendor installations and be more fully compatible with each others hardware. Existing and future commercial network systems could be made to be more interoperable, and provide more bandwidth and a higher quality of service with the assistance of these simulation tools.

REFERENCES: A Research Challenges for the Next Generation Internet., Edited by Jean E. Smith and Fred W. Weingarten, Computing Research Association, May 12-14, 1997.

KEY WORDS: QoS, Interoperability, IP/ATM, Internet, Fair Queuing, Buffer management

N99-134 TITLE: 1300nm Vertical Cavity Surface Emitting Lasers (VCSELS)

SCIENCE/TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop a new class of long wavelength VCSELS operating at 1300nm

DESCRIPTION: Current commercial and research grade Vertical Cavity Surface Emitting Lasers (VCSELs) operate in the short wavelength range making them impractical for applications over 100m or incompatible with a system already operating at the longer

wavelengths. Recent research efforts have shown that long wavelength VCSELS are possible but a number of barriers in terms of efficiency, threshold, output, and CMOS compatibility need to be resolved. Specifically, because it is not possible to vary the index of refraction sufficiently in the stacked mirrors, either 100 mirror periods are required to give the needed reflectivity or a new process such as wafer fusion is needed. The former requires extensive deposition time and the latter has not proved effective. Therefore research is required in the area of layer material composition and novel techniques for assembling mirrors and active region as well as getting the reliability to meet the current reliability of the short wavelength VCSELs. This topic seeks new and innovative designs for long wavelength VCSELs that could potentially have 1mW output and is selectively wavelength tuned (during or after wafer processing) for potential compatibility with WDM systems.

PHASE I: Develop and design using commercially available fabrication systems and techniques thermally stabilized VCSELS at 1300nm with a bandwidth of 1GHz. Show potential scale up to 1XN arrays and higher data rates. Show wavelength potential stability with temperature and a high level of integration with driver circuitry.

PHASE II: Produce prototype devices and provide on wafer and device mounted laser characterization. Provide initial temperature and lifetimes characterization. Demonstrate operational device at 1GHz, 1300nm and 100uW output up to 85C without temperature control circuitry. Develop a commercialization plan and discuss barriers to reaching a commercialized product.

PHASE III: Team with a commercial fabrication house or provide in house facilities to demonstrate production runs and document yield and reliability of device. Provide package devices to the government for further testing. Extend power levels to 1mW and demonstrate narrow wavelength devices. Demonstrate a 1XN-array device.

COMMERCIAL POTENTIAL: A low cost long wavelength VCSEL that could replace existing stripe lasers (which require external modulators) targeting the 100m to 1km digital datacom applications would have a great impact on the commercial market. Currently the standards for this area follow the telecommunications standards which are geared towards >2km applications. As a result the sources are expensive and are overkill for the fiber to the home and fiber to the curb markets. However, a low cost ruggedized device that could meet this market would also meet the navy shipboard market. The latter requires devices to operate in connector intensive environments in the 50 to 1000m range with enough power for both single mode and multimode operation and good coupling efficiencies. Additionally, devices which can be made into 1X12 arrays require high yield wafers, and low cross talk designs, but have the added benefit of small footprint and high density packaging for both serial and parallel applications.

KEY WORDS: VCSELs; GaAs; thermally stabilized; fiber optics; arrays; wafers

N99-135 TITLE: Dynamic Resource Allocation inMulti-Level Security (MLS) Environment

SCIENCE/TECHNOLOGY AREA: Command, Control and Communication

OBJECTIVE: Develop and demonstrate Dynamic Resource Allocation of computing resources in a Multi-Level Security network.

DESCRIPTION: Future Navy ships require the dynamic allocation/re-allocation of computing resources for load balancing, failure-mode reconfiguration, and response to threats. The applications operate at different security/sensitivity levels. As applications move from one resource to another, their security/sensitivity levels must move with them. A single dynamically-reconfigurable MLS network is needed because applications cannot be migrated across the physical or logical boundaries between multiple system-high networks.

The R&D technologies that might be exploited in the fulfillment of this SBIR topic include (a) software algorithms that can establish an optimum dynamic reconfiguration of a distributed-computing architecture, (b) high-performance networking that can support the movement of a large number of applications to new host machines, and (c) advanced security mechanisms that can rapidly and dynamically enable/disable the running of applications at different security levels on different host machines.

PHASE I: Develop the architecture of the dynamically-reconfigurable MLS network, identify it's security mechanisms, and develop the methodology by which applications at different security levels can migrate from one computing resource to another resource.

PHASE II: Implement the innovation in the form of a prototype demonstration of the dynamic migration of applications at different security levels. Determine the performance of the innovation in terms of time-to-reconfigure as a function of network protocol/bandwidth, host processor speed and size of application. Explore major cost and reliability issues associated with the

technology in the context of commercial viability.

PHASE III: Productize the innovation for use in military and industrial/commercial applications that require non-stop computing at different security and/or sensitivity levels. Military applications include the DD-21 ship class. Industrial applications include power-generating plants, chemical plants and steel mills. Commercial applications include global enterprises that diurnally migrate applications from one time zone to another to exploit excess computing capacity in middle-of-the-night locations.

COMMERCIAL POTENTIAL: Many industrial/commercial activities would use, and benefit from the use of, this innovation. Examples are organizations that require non-stop computing together with privacy of information at multiple security levels, e.g., financial institutions, reservation systems, electronic commerce, lottery systems, factory-floor automation, process-control systems such as steel mills, chemical plants, power generation sites, etc.

KEY WORDS: multilevel-security; MLS; dynamic-resource-allocation; security; encryption; distributed-computing

N99-136 TITLE: Development of Low Cost, Composite, Isogrid Support Structures for Large-Scale Naval Applications of Superconductivity

SCIENCE/TECHNOLOGY AREA: Conventional Weapons, Countermines/Mines

OBJECTIVE: Investigate the design and fabrication of composite isogrid structures to provide adequate support for superconductive magnets in the naval environment while minimizing thermal transfer from ambient to the magnet.

DESCRIPTION: Recent advances in refrigeration technology have eliminated the logistics burden of liquid cryogen associated with large-scale naval applications of superconductive magnets. Using mechanical refrigerators, superconductive magnets as large as 160 cm in diameter have been conductively cooled to below liquid helium temperatures (4.2 Kelvin). A large conductively-cooled superconductive magnet is part of the Advanced Lightweight Influence Sweep System (ALISS) Advanced Technology Demonstration. A key component of the ALISS system is the magnet support structure, which must be rugged to withstand the rigors of operations in the naval environment but also must have the smallest cross-sectional area possible to minimize thermal heat leak to the magnet. The ALISS magnet uses three cylindrical composite support tubes in a re-entrant configuration. However, the cost of the current re-entrant support configuration makes up more than 15% of the ALISS magnetic system cost and involves the most labor intensive step in the fabrication process. There is the potential to transition the ALISS technology to an airborne deployed mine countermeasures configuration. The current re-entrant structure design would complicate system layout.

An initial trade-off analysis indicates that a composite, isogrid structure could provide a reduced cross-sectional area to permit the use of fewer cylindrical composite supports while maintaining the required strength and low thermal heat leak. A simplified support structure could reduce procurement costs, reduce fabrication costs, reduce system weight, and provide additional arrangement flexibility.

PHASE I: Develop candidate composite materials which could be used for advanced composite supports based on strength, heat transfer, and ease of manufacture. Develop both cylindrical and conical isogrid support structures and related design issues. Design issues which should be considered include: optimization of design geometry (number of nodes and winding cross points); incorporation of a land as part of the design to permit winding the superconductive magnet directly onto the outside of the isogrid support; design of the mechanical interface between the end of the isogrid support and the system vacuum vessel; and, design of intermediate thermal intercepts. Identify manufacturing issues, perform preliminary tooling design, and develop a manufacturing approach.

PHASE II: Fabricate several test articles of a length and a diameter appropriate for an airborne deployed mine countermeasures system. More than one of the geometries examined in PHASE I can be produced if the trade-off study performed in PHASE I shows a close comparison. Determine the mechanical properties of the isogrid test articles, including compressive strength, tensile strength, and flexural strength. Determine the thermal conductance of the test article.

PHASE III: Support transition of superconducting magnetic devices to general Naval applications, including propulsion machinery and weapon launcher applications.

COMMERCIAL APPLICATION/ DUAL USE: Potential commercial applications include magnetic resonance imaging (MRI) medical devices, magnetically levitated transportation systems, and advanced physics systems used to conduct experiments requiring

high magnetic fields. In addition to mine countermeasures, superconductive magnet systems are being evaluated for naval applications in electric propulsion machinery, energy storage, and advanced launcher applications. Isogrid structures which provide a high strength, low heat leak support system would be an enabling technology for these military applications.

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KEY WORDS: superconductivity; isogrid; composite; cryogenic

N99-137 TITLE: Innovative Techniques To Improved Combat Information Center Processes

SCIENCE/TECHNOLOGY AREA: Manpower and personnel

OBJECTIVE: Reduce manpower requirements for Surface Combatant Combat Information Center operations.

DESCRIPTION: Innovative techniques and methods are required to support the Navy's SmartShip Project's initiative for reducing the manpower requirements for Combat Information Center (CIC) operations. Typically, a modern Destroyer or Cruiser requires 45 crewmembers at Battle Stations to effectively conduct CIC operations, which involve collecting, processing, evaluating, displaying, and disseminating the required data to fight the ship. Planned enhancements to surface ship communication connectivity and networking within the battlegroup as well as ship to shore, will support high order of improvements to traditional CIC processes. Areas of interest include, but not limited to: The intelligent integration of information from various sensors using extended methodologies for designating target location and identification; Visualization technologies that leverage the advances in connectivity/networking and focus on increasing the effectiveness of CIC operations ; leading edge technologies in the areas of optics and digital video processing; innovative approaches in enhancing visualization of realistic images of objects/targets within the simulated battlespace.

PHASE I: Develop new concepts and describe or model both the current Surface Combatant CIC processes and the improvements resulting from application of the new concepts. Include data transport delays (senessence) and other effects associated with each process step, (eg: operators), in the description of the current an improved processes. Identify the procedures, methods and new equipment required for the process implementation, and develop an implementation strategy.

PHASE II: Demonstrate the new concepts, including the expected/predicted improvement(s), from Phase I at Navy's SmartShip Project ACIC of the Future landbased prototype. Inlcude any applicable and/or prototype equipment form Phase I in the demonstration.

PHASE III: Demonstrate the new concepts and/or prototype equipment on a selected ship.

COMMERCIAL POTENTIAL: All Operations Centers and Control Stations for transportation industries could utilize improved processes.

REFERENCES: Configuration Definition Document for AEGIS Guided Missile Destroyer # N010-003.

KEY WORDS: Information, Manpower, Visualization

N99-138 TITLE: Microwave High Power Limiter

SCIENCE/TECHNOLOGY AREA: communications

OBJECTIVE: Develop a C-band high power (250 watts minimum) limiter for military communication systems.

DESCRIPTION: As the trend toward smaller and higher power microwave communication systems continues, the requirements

of the individual components become more demanding. Solid state and vacuum devices continue to become more powerful. Protection against these higher power levels must be provided for expensive, power sensitive circuits. As an example, the Cooperative Engagement Capability (CEC) Airborne Transceiver system currently uses solid state FETs to generate power levels up to 100 watts. This power level approaches the limit of current limiter technology. As the system power level is increased (via Microwave Power Modules or higher power FETs), the power capability of the limiter must correspondingly increase to protect against component failure. For airborne and joint service applications, CEC has the need to increase RF power to meet current operational requirements.

PHASE I: Design a high power C-band limiter that can handle power levels of 250 watts or greater. Design(s) should be for a ground base environment and an airborne environment. Size/weight of the design should be minimized. The detailed specifications will be generated. The design shall include detailed electrical and a mechanical analysis.

PHASE II: Create fabrication drawings and build a prototype limiter. Tests shall be conducted to verify power handling capability, insertion loss, VSWR, flat leakage, and recovery time. Temperature and altitude testing shall also be conducted to assess the performance of the limiter in a military environment. Prepare a report that includes all design parameters and test results.

PHASE III: Fabricate one set of limiters for insertion into a CEC transceiver system with high power devices for demonstration testing.

KEYWORDS: high power microwave limiter, Microwave Power Modules, electronics device

N99-139 TITLE: Non-Metallic Netting for Deck Edge Safety Nets

SCIENCE/TECHNOLOGY AREA: Materials

OBJECTIVE: Select an alternative non-metallic netting material with a lower life cycle cost as a replacement for nylon netting on ships where Electromagnetic Interference (EMI) and weight are a concern.

DESCRIPTION: Non-metallic netting is required in areas not subject to high heat in order to reduce topside EMI effects, and to save weight on weight and/or stability critical ships. Historically, nylon netting has been used to meet this need; however, nylon netting degrades in sunlight and requires replacement on an annual basis. This effort would investigate alternative lightweight non-metallic materials that can withstand sunlight, abrasion, and not deteriorate in a seawater environment in order to extend the replacement periodicity and to reduce the life cycle costs of non-metallic netting for deck edge safety nets.

PHASE I: Perform material studies to identify non-metallic materials suitable for fabricating netting for deck edge safety nets. Evaluate each material for strength; weight; ease of fabrication; resistance to sunlight, saltwater, temperature, fire, abrasion; availability; suitability for this purpose; and life cycle cost. Develop an environmental and strength test procedure, perform environmental and strength testing of the most highly rated candidate materials, and evaluate and report the findings. The specific materials properties goals are: minimum breaking strength of 3500 pounds; 125% weight of nylon (maximum); producible using existing technology and equipment at a cost not to exceed 150% of current production cost for nylon netting; resistant to direct sunlight and saltwater for 5 years (minimum); no loss in strength up to 175 degrees F and down to B40 degrees F; fire resistance greater than or equal to nylon; resistant to wind-load abrasion for 5 years minimum.

PHASE II: Develop prototype designs for fabrication of nets and an evaluation plan to test and evaluate the top candidate materials in a shipboard environment. Fabricate and install candidate netting on the selected test platform. Conduct periodic inspections, and analyze and report findings to determine the expected life of candidate materials.

PHASE III: Prepare a field test report, analyze results, and select a replacement material. Develop or revise fabrication procedures, installation procedures, and in-service testing procedures for replacement material. Revise appropriate standards, drawings, and logistical data to reflect replacement material usage.

COMMERCIAL POTENTIAL: The selected replacement material could be used in cargo nets and other commercial applications where ultraviolet stability and strength are required.

KEY WORDS: Non-metallic, nets, nylon, EMI, weight, cost

N99-140 TITLE: Virtual Distributed Real-Time Operating System for Real-Time Combat Systems and Joint Systems Like CEC

SCIENCE/TECHNOLOGY AREA: Computer Sciences; Computers, Software

OBJECTIVE: To develop a virtual real-time framework for integrated platform combat systems and joint warfare coordination systems which will present a long term solution framework to guide in designing wrapper ware and middle ware, which meets the real-time processing requirements, and which supports fault tolerance, redundancy, reconfiguration, and graceful degradation requirements of advanced distributed systems.

DESCRIPTION: Commercial distributed real-time operating systems have requirements which are very similar to the requirements for middle ware to support an integrated platform real-time combat system or coordination system. Middle ware provides the glue which holds together the distributed processing assets and processes of a combat system or coordination system. Middle ware for these systems can be viewed abstractly as a Virtual Real-Time Operating System. Combat and coordination system middle ware can be designed as a Virtual Real-Time Operating System providing real-time, multi-thread operating system capabilities by using current commercial operating system technology and principles. The Virtual Real-Time Operating System for combat or coordination systems must address fault tolerance, redundancy, reconfiguration, and graceful degradation issues like fault latencies, failure modes, and battle damage concerns. Research into application of the same concepts and principles used in distributed real-time, multi-thread operating systems to defense related systems could provide major improvements in combat and coordination system design which is the objective of this research project.

PHASE I: Research and design a Combat System or Coordination System Middle ware Virtual Real-Time Operating System. Examine commercial operating system technology and hardware architecture to find parallel requirements. Document results in a Phase 1 report.

PHASE II: Develop a design process which incorporates the techniques, architectures, and approaches from Phase 1 in design of an integrated combat or coordination system for different architectures options that are considered feasible for combat systems or coordination systems. Document the processes, techniques, and alternative architectures in a Phase 2 report.

PHASE III: Incorporate the techniques, processes, and architectures into the design of commercial systems with the same fault tolerance, redundancy, reconfiguration, graceful degradation, and real-time requirements needed for military combat and joint force coordination systems but also extends the processes, techniques, and architecture alternatives to fit into the COTS hardware and software design framework. Phase 3 includes development of tools to support the process with COTS hardware and software.

COMMERCIAL POTENTIAL: Real-time control systems with fault tolerance, redundancy, reconfiguration, and graceful degradation requirements need a process and tool sets to provide the same high level of quality and reliability required by defense systems but the commercial sector does not have the same research resources that DOD has to design the process and tool set.

KEY WORDS: Real-Time; Distributed Processing; Command and Control; Combat System; Coordination System; Operating System

N99-141 TITLE: Automation & Software Development for Material Handling/Categorizing Systems

SCIENCE/TECHNOLOGY AREA:. Computers, Software

OBJECTIVE: Automate categorization, nesting, and handling of steel plate used in fabricating structural shapes (i.e. I-beams, T-beams).

DESCRIPTION: This effort would expand existing software capabilities to support dynamic nesting of parts and remnants and the optimum relationship between individual parts to support fabrication into a final component. Software to plan and automate the usage and handling for steel plating and other materials has been demonstrated as a useful tool to optimize scheduling and procurement of materials in a manufacturing environment, but is limited in capabilities required for structural components and manufacturing applications.

PHASE I: Develop user-friendly software modules and tools to dynamically categorize, sort, and arrange lightweight

materials used to fabricate structural components. Utilizing a manufacturing schedule, this software should be able to distinguish between different parts, develop a relationship between parts needed for a particular shape, nest parts without log jamming the system, and dynamically handle remnant parts.

PHASE II: Integrate the Phase I software into commercially available handling systems and test & Demonstrate and evaluate its ability to sort and handle light weight steel plate used in fabricating structural shapes.

PHASE III: Package user friendly software to allow the shipbuilder or other manufacturing facility to input scheduling requirements for fabrication of parts.

COMMERCIAL POTENTIAL: This software could be applicable to any manufacturing facility which fabricates structural components from lightweight steel plates.

KEY WORDS: Automation, software, nesting, handling, plating, structural .

N99-142 TITLE: Virtual Prototype Methodology for Radar Digital Signal Processor Development

SCIENCE/TECHNOLOGY AREA: Modeling and simulation

OBJECTIVE: Develop a methodology based upon the ARapid Prototyping of Application Specific Signal Processors (RASSP) Program for applying simulation based, virtual prototyping technologies throughout the life cycle of modern radar digital signal processors.

DESCRIPTION: Modern radars perform multiple functions. The design and development of the signal processors for these radars poses several significant technical challenges. First, the signal processors have to process large volumes of data in response to a rapidly changing stream of waveforms or modes. Secondly, the processing performed in each mode is to be accomplished with low latency times. Lastly, the signal processors are expected to be readily adapted to perform new processing or new missions and to readily accommodate component evolution or obsolesce. To meet processing and adaptability demands, massively parallel processor architectures (MPP), based on using large numbers (100s) of programmable processors, are being considered. A recognized problem faced with using this approach to a computing architecture is the lack of a methodology (process, software tools, etc) for evaluating of alternative processing architecture decisions throughout the life cycle. One approach identified for addressing this problem is the use of simulation based technologies. However, there are several shortcomings in current day simulation based technology which impede its use. There is a need for innovative efforts to determine and demonstrate the use of simulation based technology throughout the life cycle of modern radar digital signal processors.

PHASE I: Define a methodology for applying simulation based approaches to the development and continued evolution of signal processing architectures for modern radars. Develop and document requirements and identify candidate software tools that could be used to support the methodology. The virtual prototype methodology should build upon the RASSP technology developed by DARPA.

PHASE II: Implement a portion of the simulation based methodology using currently available software tool(s) and demonstrate its use in the design of a modern radar signal processor (demonstration tool(s) to be agreed upon jointly by the Contractor and the Governemnt).

PHASE III: Develop a fully functional simulation based methodology for use with modern radars.

COMMERCIAL POTENTIAL: Demands of radar signal processing, combined with long life span requirements are greater than those currently found in commercial applications. Enhancements to software tools and methodology are likely to guide capabilities provided in commercially available tools. Further, the use of parallel processing architectures in commercial applications (e.g., medical visualization or rendering, data mining) as well as civilian radar applications (e.g., air traffic control) has been slow due to the lack of suitable tools and methodologies. Innovations resulting from this effort will facilitate broader commercial use of parallel processing technology.

REFERENCES:
1) Simulation of Communication Systems, Jeruchin, Balaban, Shamugan, 1992, Plenum Press, NY.
2) AVIUF Fall 1997 Conference, Rapid Systems Prototyping with VHDL, October 19 - 22, 1997, Arlington, VA.

KEY WORDS: Radar; parallel processor; virtual prototyping; life cycle; RASSP; DSP

N99-143 TITLE: Aluminum Nitride Infrared Window

SCIENCE / TECHNOLOGY AREA: Materials

OBJECTIVE: Develop a method to produce aluminum nitride seeker windows that are transparent in the 3- to 5-micron wavelength infrared region.

DESCRIPTION: Sapphire is the current material of choice for mid-wave infrared seeker windows on high speed missiles because it has the greatest thermal shock resistance of any available window material. Materials with twice as much thermal shock resistance are required for hypersonic missiles that are currently being planned. Aluminum nitride can potentially meet this requirement. Aluminum nitride has a strong birefringence, which has so far prevented the fabrication of transparent polycrystalline materials. Birefringence causes significant optical scatter which cannot be tolerated in a seeker window. The goal of this program is to fabricate single crystal or polycrystalline (nanocrystalline) aluminum nitride with a thickness of 2 millimeters, less than 2 percent scatter at a wavelength of 4 microns, an absorption coefficient less than 0.1 per centimeter at a wavelength of 4 microns, and a thermal conductivity above 160 watts per meter-kelvin at room temperature.

PHASE I: Demonstrate the feasibility of fabricating aluminum nitride with at least 65% transmittance at a wavelength of 4 microns when the thickness is at least 1 millimeter.

PHASE II: Refine the process to prepare aluminum nitride disks with dimensions of at least 2 millimeters thickness and 25 millimeters diameter with the following properties: < 2% scatter at 4 microns; absorption coefficient < 0.1 per centimeter at 4 microns; and thermal conductivity > 160 watts per meter-kelvin 20EC. Material meeting the optical requirements will have a transmittance of 74% at 4 microns. Measure the mechanical strength of optical quality disks (25 mm diameter x 1.5 mm thick) using ring-on-ring flexure. Strengths should be measured on 20 disks at 20EC and 20 disks at 600EC. Target strengths are >200 megapascals at both temperatures.

PHASE III: Transition fabrication technology into a production facility capable of manufacturing 90-millimeter-diameter hemispheric domes (thickness ' 2.5 mm) or flat rectangular windows with dimensions up to 100 mm x 200 mm (thickness ' 5 mm) for use in a selected hypersonic missile system. Establish a database of physical properties including thermal conductivity, mechanical strength, modulus, expansion coefficient, and optical absorption coefficient as a function of temperature up to 1000EC. Develop an antireflection coating that provides >90% transmittance in the wavelength range 3-5 microns for 2.5 mm thick parts coated on both sides. Measure the change in transmittance of bare aluminum nitride and antireflection-coated aluminum nitride in rain and sand erosion experiments.

COMMERCIAL POTENTIAL: Aluminum nitride will be available for military and civilian applications such as windows for optical monitors in high temperature manufacturing processes, optical sensors in turbine engines, and optical sensors in power plants. High quality aluminum nitride has potential as an electrically insulating, heat spreading component in high power electronic components including high density integrated circuits and microwave components.

REFERENCES: D. C. Harris, "Infrared Window and Dome Materials," (ISBN 0-8194-0998-7) SPIE Press, Volume TT10, 1992

KEY WORDS: ceramics, aluminum nitride, thermal shock, infrared window, infrared dome; infrared seeker

N99-144 TITLE: Novel Gun Pointing Scheme

OBJECTIVE: Develop a gun pointing scheme best suited for launching guided projectiles in a long range fire support role. The pointing scheme should allow the gun to be installed and operated below deck, installed in a module, and should minimize the weight

and volume impact on the ship. Additionally, the concept should allow active and passive techniques for reduction of thermal, radar, and muzzle-blast signatures.

DESCRIPTION: The Naval Surface Fire Support (NSFS) program wishes to explore the design space of very long, efficient gun barrels made of modern engineered materials. Current guns, which must train, elevate, and recoil, have a major impact on the ship and on the other systems onboard. Attempting to install a long, powerful gun of classic design would produce a ship that was dominated by this single weapon. This topic seeks approaches to take advantage modern materials and designs to produce a long gun barrel that can be integrated more readily into the ship. The key feature of this gun is a vertical mounting, with a bendable barrel to provide train and elevation over a limited arc. To achieve this property, the barrel must be composed of anisotropic materials such as metal-matrix composites, which provide high hoop strength while permitting some degree of axial bending. Augmenting this structure, the inside of the barrel must be an advanced liner and coating system to support propellant temperatures up to 2900 K. Outside of the barrel's pressure vessel is an external truss that provides the bending forces to steer the barrel as well as a signature-management system to provide cooling, radar and thermal signature hiding, and a muzzle brake/exhaust blast management and cooling system. The intention of this SBIR topic is to explore the feasibility of this design, and the suitability of materials to support it, in a subscale model that can, if successful, be implemented in a 5-inch barrel 160B200 calibers long.

PHASE I: Complete a prototype structural design of the metal-matrix barrel in a subscale size. Dynamically model the structural response of the barrel during firing, optimized the design of the external stiffening/train-and-elevation device, and evaluate the effects of the design on projectile tip off and in-bore balloting forces.

PHASE II: Fabricate a subscale barrel for single-shot firing, validate the structural design and response predictions, and incorporate signature reduction features into the design.

PHASE III: Fabricate a 5-inch gun based on the Phase I designs. Integrate signature reduction treatments and muzzle blast reducer into a demonstrator/prototype.

COMMERCIAL POTENTIAL: New metal refractory materials and anisotropic metal structure designs have great potential in the commercial automobile and aircraft industries. The maximum operating temperature of the hot parts of almost any engine in use today is the primary limitation of their thermodynamic efficiency. A new sintered oxide refractory alloy being developed for gun applications possesses all the desirable properties for today's high-efficiency engines. Similarly, metal-matrix materials provide an important bridge between isotropic metals and composite/epoxy for high strength/high temperature applications. More importantly, metal-matrix materials combine the advantages of these materials without most of the disadvantages. The signature reduction aspects of this topic also have direct commercial application. Infrared cross-section treatments also have application to thermal insulation, particularly for industrial equipment such as steam power plants, chemical plants, and heavy equipment engines. Radar cross-section reduction treatments can be used to reduce electromagnetic interference, particularly co-site problems. These problems are increasing as localities restrict the erection of new cellular telephone base station towers. Other changes that exacerbate EMI problems are the new 940 MHz Personal Communications System licenses, wireless computer LANs, and crowding of satellite earth stations by point-to-point microwave. Of note, the April 1997 issue of Microwave Journal includes ads from four manufacturers of RF absorbing material and solutions to co-site interference problems.

KEY WORDS: gun barrel; metal matrix; radar; cross section; infrared; absorption

N99-145 TITLE: Multi-Sensor Correlation Displays

SCIENCE/TECHNOLOGY AREA: Sensors, Software Computing

OBJECTIVE: Develop new display formats that facilitate multi-disciplinary and multi-sensor presentation of data on reduced manpower 21st century surface combatants. Develop an effective means to efficiently manage, visualize, and evaluate the typically high volume of rangeless information such as Electronic Warfare against localized Combat System data.

DESCRIPTION: Proposed manpower limitations on the new surface combatants will require the use of innovative combat system display techniques. Operators from multiple disciplines will be required to use a common set of displays that will present multi-sensor data. A common display concept is vital to the multi-disciplinary aspect of this system. Current Combat System display methods of simultaneously presenting ranged and rangeless data have proved unsuitable for integration of such domains as Radar,

Electronic Warfare and Sonar where there is a high incidence of non-correlated rangeless sensor data. Improvements to the traditional methods of integrating the visual representation of multi-sensor data for both ranged and rangeless data while preserving geo-spatial and tactical situation awareness can greatly improve the fleet's effectiveness while reducing the operator's workload. Interfaces to the various sensor systems are necessary to include their data on a common set of displays. The displays should give the operator access to data, not only contacts, without requiring the operator to drill down into unfamiliar display systems; The displays should be capable of presenting data and contacts in an effective and efficient manner. Consideration should be given to the ability to overlay multiple data types (at the contact or data level) effectively and the presentation of logical guides to orient the operator to the scenario quickly. Development of automation type tools to help operators manage and follow multiple data types on the display is vital.

PHASE I: Develop innovative display storyboards which demonstrate candidate data rendering techniques within specified Combat System Guidelines sufficient to solicit and incorporate fleet feedback and refinement.

PHASE II: Design and fabricate a proof of concept prototype display which incorporates the techniques developed during Phase I of this effort.

PHASE III: Full development and production for application to Electronic Warfare and other Systems.

COMMERCIAL POTENTIAL: Display techniques developed can be transferred to a variety of commercial and military applications to include airborne and sonar sensor systems, air traffic control, and drug interdiction.

KEY WORDS: Data Fusion, Electronic Warfare, Displays, and Advanced HMI

N99-146 TITLE: Body-to-Body Penetration and Damage Models

SCIENCE/TECHNOLOGY AREA: Modeling and Simulation

OBJECTIVE: Develop a fast-running, analytical/engineering methodology and computer code to predict terminal ballistic interactions between complex structures.

DESCRIPTION: The Navy is striving to develop more effective anti-air missile systems to defeat tactical ballistic missiles (TBMs) as well as cruise missiles and aircraft. Damage from direct hits by interceptor launched projectiles is the primary mechanism for defeating TBMs for some concepts. Analytical methodologies are required to evaluate new concepts, optimize weapon designs, and evaluate system effectiveness. Current lethality assessment methodologies either calculate the projectile projected area that is swept through the target, or use a hydrodynamic crater algorithm which requires homogenized target and projectile density and strength properties, as well as numerous other assumptions. As such, single penetrator methodologies do not account for the effect of target responses (e.g., target element acceleration and material removal) from earlier impacts on the encounter conditions and target response for later impacts. The temporal resolution of terminal ballistic target loading and response is needed for accurate weapons effects assessments associated with both single and multiple homogeneous penetrator impacts, as well as impacts between complex, spatially extended structures. The utility of hydrocodes to optimize designs and evaluate effectiveness is limited because of run-time, costs, required expertise, and the inability to use them in higher level simulations. New concepts in modeling are needed to predict body-to-body penetration and target damage in a fast-running, yet sufficiently accurate way.

PHASE I: Identify the geometric, kinematic, and dynamic loading and response problems associated with ballistic impacts between complex structures over a range of intercept velocities. Describe the main features of the objective prediction methodology, including interceptor and target geometry, physics- based terminal ballistic loading and response models, and their time resolution. Develop an understanding and sensitivity of the more important parameters involved. Provide a limited demonstration of the key concepts.

PHASE II: Develop the objective prediction methodology and a fast running computer code for use in lethality assessment and system effectiveness studies. Demonstrate its application for a selected complex projectile/target combination of current interest. Plan experiments to validate the models. Validate the computer code by comparison with experimental data and selected numerical simulations.

PHASE III: Improve and extend the model and implement it into lethality assessment and system effectiveness simulations used by the weapon development community.

COMMERCIAL POTENTIAL: Utilization of the methodology in government and commercial vulnerability/lethality and risk

assessment computer codes and as an aid to weapons design and protective structure design. Potential applications include vehicle crashworthiness analyses, accident investigation, design of containment structures for industrial accident debris, design of hazardous materials shipping containers, anti-terrorist barriers, and vehicle armor.

KEY WORDS: direct hit; body-to-body; projectile; penetration; lethality; vehicle damage

N99-147 TITLE: Mission Planning for Tactical Shipboard EW Systems

SCIENCE/TECHNOLOGY AREA: Software, Electronic Warfare Technology

OBJECTIVE: Develop a methodology for the utilization of a wide variety platform, sensor and weapons intelligence databases, emitter intercept logs and mission objectives to adapt tactical shipboard EW sensor resources and responses.

DESCRIPTION: Existing tactical EW systems currently utilize databases generated by land based intelligence centers that can not be adapted to dynamically changing conditions. Emitter/Platform associations, platform location and emitter parameters may change faster than intelligence centers can cycle updates to the affected tactical shipboard EW system. Tactical shipboard EW users need the ability to analyze the various intelligence databases, visualize anticipated sensor and weapons coverageís, and visualize emitter intercept logs from organic and non-organic sensors. Utilizing this information, the tactical shipboard EW user should be able to generate system resource management doctrine, which adapt tactical shipboard EW sensor resources and responses for the mission.

PHASE I: Identify existing databases that can support the specific tactical shipboard EW system. Identify methods to allow the tactical shipboard EW system user to visualize the anticipated environment. Identify tools that allow the tactical shipboard EW user to adapt reference databases to the anticipated environment. Identify tools to develop and test resource management doctrine. Define innovative hardware and software elements, development and operational software environments and identify a real-time application with which to demonstrate the architecture.

PHASE II: Demonstrate a new integrated architecture composed of a state-of-the-art processor configuration which makes maximum use of off-the-shelf components, open system architecture, relies on commercial industry standard communication media and physical connections, and drastically reduces the number of unique components. This effort should show that the existing defense computing system components could be upgraded and/or changed without extensive application code development.

PHASE III: Full development and production for application to Electronic Warfare Systems.

COMMERCIAL POTENTIAL: Commercial applications for situation awareness visualization techniques, integrated database analysis tools and tools that allow the user to develop rules to optimize system resource include: FAA Air traffic control ñ Sensor Mapping, Weather Mapping, AIR Traffic Routing with re-routing rules; Cellular telephone and Pager Systems ñ Tower Site Coverage Mapping with Interference and outage re-routing rules; Commercial Satellite ñ Coverage, Interference control with bandwidth utilization rules; Internet ñ Site mapping, Message routing and re-routing rules. In each of the above applications, geographic mapping displays integrated with a database with interactive database query mechanisms with innovative data visualization techniques allow the commercial user to plan for and respond to very dynamic situations.

KEY WORDS: Database visualization, rule based resource management, COTS, real time computing systems, and signal processing.

N99-148 TITLE: Improved Time and Frequency Standards for Gun-Launched Projectiles

OBJECTIVE: Develop rugged time and frequency standards to support GPS navigation of gun-launched projectiles

DESCRIPTION: Current guided projectiles are constrained by performance limitations on their frequency references. Current crystal frequency references are acceptable but increased accuracy will require new frequency reference. The frequency reference provides both a frequency reference for the receiver and a time reference for the spread-spectrum code. Before launch, the frequency and time references are synchronized and biases are estimated and compensated for. These events happen as part of fuze setting, along with entry of aimpoint, ship's position, and GPS satellite ephemeris data. The frequency reference must maintain these references during

this time, through the shock of gun launch, until the receiver acquires. It must be able to maintain its performance despite temperature variations ranging from B40EC storage for Marine Corps and Army ammunition in the field, to 200EC after loading into a hot gun. For shipboard use, the delay between synchronization and firing is typically short, (tens of seconds) but may be extended by interruptions in the firing process, test/exercise constraints, or misfire of the gun. For field use, the delay is typically longer, up to two minutes. This topic will ask for a significant performance improvement and cost reduction over the current quartz crystals, for which the following characteristics are given. Performance is particularly desired in shock survival, with an objective of 30,000 g. Improvements in stability (that is, frequency sensitivity to shock and thermal changes) is also desired.

Current reference frequency

Shock environment: Setback: 16,000 g (g = 9.8 m/sec2) 3 ms rise time, 10 ms duration. Lateral Balloting: 3,200 g. Setforward: 4,000 g, 0.3 ms rise time. Launch Vibration (RMS): 6 g, 20 to 2000 Hz. Maximum Roll Acceleration: 50,000 Hz/s. Maximum Roll Rate: 250 Hz.

Shock induced frequency shift: "1.5 parts per million

Thermally-induced frequency shift: "1.5 parts per million over the range 10ECB70EC

Output frequencies: 10,949,297 Hz and 21,898,594 Hz

Output Signal: CMOS Digital, driving 2 standard CMOS loads

Power Input: 5 V "5%, voltage noise 10 mV p-p 10 kHz to 2 MHz

Power Consumption: 220 mW

Aging: "2 parts per million per year

SSB Phase Noise at 43,797,188 Hz: 10 Hz, -80 dBc; 100 Hz, -100 dBc; 1 kHz, -130 dBc, 10 kHz, 0135 dBc.

PHASE I: Develop a design for the time and frequency reference, and demonstrate any key process or component steps.

PHASE II: Fabricate prototypes and demonstrate their performance under high-g launches in an air gun or rail gun. The demonstration should include enough samples to provide confidence that the reference will consistently survive and maintain their performance.

PHASE III: Incorporate the reference into Navy, Army, and Marine Corps guided projectiles such as the EX-171 Extended Range Guided Munition, XM-982, and Competent Munition ATD guidance unit.

COMMERCIAL POTENTIAL: This product is directly applicable to commercial GPS applications, particularly high-shock or vibration environments such as vehicle and cargo tracking, instrumentation for destructive testing, and construction, as well as time and frequency standards for data communications in those same environments.

REFERENCES:

1. System Specification for the CMATD GN&C Enhanced Artillery Round, C. S. Draper Laboratory, Inc. 11 June 1997

2. Subsystem Specification for the CMATD G-Hardened Precision Oscillator and TCXO Electronics, C. S. Draper Laboratory, Inc. 11 June 1997

KEY WORDS: clock; oscillator; resonator; quartz; time; frequency; GPS

N99-149 TITLE: Alternative Manufacturing Techniques for Thermal Batteries

SCIENCE/TECHNOLOGY AREA: Aerospace propulsion and Power

OBJECTIVE: Improve energy density of thermal batteries used in missile applications.

DESCRIPTION: Present manufacturing techniques for manufacturing thermal batteries utilize pressed powders for the anode, cathode, electrolyte and heat pellets. Alternative methods for manufacturing such as tape casting, vapor deposition or laser ablation may offer improved energy density if applied to the manufacture of thermal batteries.

PHASE I: Investigate alternative methods for manufacture of thermal battery cells for use in missile applications. Deliverables might include: identification of challenges, evaluation of issues of size, weight, form-factor, thermal management, safety, mechanical and chemical stability, high voltage use (>160V) and pulse power capability (>300A); demonstration of selected technology.

PHASE II: Deliver prototype batteries manufactured using method(s) selected in Phase I for evaluation against existing

technology.

PHASE III: Development of a battery capable of fully satisfying mission requirements for an existing missile system.

COMMERCIAL POTENTIAL: This technology would have application in areas concerned with emergency electrical power, as well as the metallurgical industry.

REFERENCES: Linden, David, "Handbook of Batteries and Fuel Cells", 2ed.

KEY WORDS: electrochemical; battery; thermal; power; anode; cathode

N99-150 TITLE: Enhanced Platform Tracking Based on Multiple Emitter Reports Detected by a Single Sensor System

SCIENCE/TECHNOLOGY AREA: Sensor

OBJECTIVE: Develop a methodology for effectively applying existing emitter contact tracking and correlation techniques to group and platform tracking requirements.

DESCRIPTION: Existing tactical EW systems currently perform emitter contact tracking. Multi-emitter correlation is performed on these systems to enhance identification. However, when emitters are no longer detected by the system, knowledge of emitter relationships to the source platform is removed. When the emitter signal is re-acquired by the sensor, the system must perform re-correlation. Each time re-correlation is performed, the system typical carry forward no prior knowledge of past associations and any knowledge imparted by operators or other correlation functions is lost. By implementing a long term tracking algorithm coupled to a multi-emitter platform correlation algorithm the need to continuously perform re-correlation can be reduced, emitter identification can be enhanced and improved situation awareness of the platform operations can be achieved.

This effort will assess the viability of combining existing emitter contact tracking algorithms and existing correlation algorithms into a tightly coupled algorithm.

PHASE I: Develop emitter contact tracking and emitter correlation algorithms that exhibit performance characteristics needed to support multi-emitter platform tracking.
This effort will define innovative hardware and software elements, development and operational software environments and identify a real-time application with which to demonstrate the architecture.

PHASE II: Demonstrate a new integrated architecture composed of a state-of-the-art processor configuration which makes maximum use of off-the-shelf components, open system architecture, relies on commercial industry standard communication media and physical connections, and drastically reduces the number of unique components. This effort should show that the existing defense computing system components could be upgraded and/or changed without extensive application code development.

PHASE III: Full development and production for application to Electronic Warfare Systems.

COMMERCIAL POTENTIAL: Any commercial computing system could benefit from multi-report tracking and correlation technology. Potential markets include commercial manufacturing industry and air traffic control.

KEY WORDS: Emitter tracking, group tracking, platform tracking multi-emitter correlation, COTS, real time computing systems, and signal processing.

N99-151 TITLE: Optimization of the Ultra Broadband Radiation Source

SCIENCE/TECHNOLOGY AREA: Electronic Warfare

OBJECTIVE: Enhance the attractiveness of the ultra broadband, high average power radiation source for IR countermeasure applications by providing modifications that reduce its weight, size and cost.

DESCRIPTION: Recently, a new approach has been proposed for generating high average power ultra broadband radiation by

beating two CO2 laser beams with slightly different frequencies in a nonlinear medium. More recent studies have shown that such a source can produce high average power radiation in every IR atmospheric window of interest and therefore, it has the potential to provide efficacious countermeasures for high value, high signature platforms, which presently have only limited protection. Although the source has several attractive features, further improvements on its weight, size and cost would be desirable. Specifically, the replacement of the two CO2 lasers with a single laser would substantially reduce the weight, size and cost of the system.

PHASE I: Develop one or more concepts that are capable of providing two lines with closely spaced frequencies using a single CO2 driver. Assess relevant proof-of-principle experimental data. In addition, provide reliable weight, size and cost estimates and determine the efficiency of the system and the directional properties of the radiation.

PHASE II: Design, fabricate and test a radiation source that is based on the conceptual design of Phase I. Assess its suitability for countermeasure applications.

PHASE III: In partnership with industry develop a high average power prototype jammer having the desired repetition rate capability.

COMMERCIAL POTENTIAL: Ultra broadband, high average power radiation sources have a host of civilian potential applications, including active remote sensing of atmospheric pollutants and wireless communication. In addition, they may benefit from the various law enforcement agencies, since they may power DIAL sensors that have the potential to remotely detect the atmospheric molecular constituents of narcotics during processing activities as well as of explosives stored in large containers.

REFERENCE: Sprangle, P., et al., Naval Research Laboratory Memorandum Report NRL/MR/6790-96-7805.

KEY WORDS: Countermeasures; Lasers; Nonlinear Optics; Ultrabroadband Source; High Power; IR

N99-152 TITLE: Power Beaming of Millimeter-Waves for UAVs

SCIENCE/TECHNOLOGY AREA: Electronic Warfare

OBJECTIVE: Develop a capability to power UAVs by beaming millimeter-wave power from a transmitter to the UAV, and converting the received energy into electrical power by means of a rectenna (a half-wave dipole array with integrated diode rectifiers). This should permit prolonged mission duration compared to other means of powering UAVs, including onboard batteries. For near-ship applications, this would avoid the requirement of using tethers to provide the power. By proper choice of operating frequency, in order to operate either near an atmospheric window or an atmospheric absorption line, a suitable trade-off should be achieved between mission range and operational covertness.

DESCRIPTION: Small Unmanned Airborne Vehicles (UAVs) are of considerable interest for a variety of tactical military missions. Ship-based UAVs are being developed by the Navy as decoys and sensor platforms which should maintain a position within a few 100 m of the ship. Current prototypes make use of tethers to provide the power, which limits their performance. Also, very small airborne vehicles micro-AVs with a wingspan of a few inches are being considered are being considered for missions such as covert surveillance, jamming of targeting radars, and target designation. Battery-powered micro-AVs would be limited to mission duration of a few minutes. For both UAVs and micro-AVs, millimeter-wave power beaming could provide the power for indefinite-duration missions, with powers ranging from tens of watts for micro-AVs to a few kilowatts for UAVs. The use of millimeter-waves, rather than longer wavelength microwaves, can provide the necessary range capability with acceptable antenna sizes. Commercial high-average-power gyrotrons can provide the millimeter-wave power at the transmitter. Rectennas on the UAV or micro-AV can in principle convert the millimeter-wave radiation into electrical power with an efficiency of ~50%. The key limiting factor in developing prototype power beaming systems is the present state of the art of rectenna development. The Navy is interested in further prototype rectenna development in support of future power-beaming systems

PHASE I: Develop and test a 35 GHz prototype rectenna to produce 20 W of DC power. Carry out a design study addressing issues of power, range, efficiency, optimum frequency, and potential covertness of power beaming to UAVs and micro-AVs.

PHASE II: Develop and test rectennas at either 60 or 94 GHz, depending on evaluation of issues of range versus covertness. Develop a rectenna to produce at least 20 W of DC power with 50% conversion efficiency. Integrate rectenna in 16 inch wing-span of micro-AV prototype.

PHASE III: In partnership with industry, develop a complete micro-AV power beaming system, that includes a source of 60 or 94 GHz radiation, a transmitter-tracker, and a micro-AV powered by millimeter-wave radiation. Develop methods for low-cost manufacturing of rectenna systems.

COMMERCIAL POTENTIAL: Micro-AVs with long-duration flight capability powered by millimeter-wave power beaming may have application to civilian law enforcement, drug control, or border patrol agencies for covert surveillance applications.

REFERENCES: T.-W. Yoo and K. Chang, Theoretical and Experimental Development of 10 and 35 GHz Rectennas, IEEE Trans. Microwave Theory Tech., vol. 40, p. 1259-1266, June 1992; Palmtop Planes, New Scientist, 5 April 1997, pp. 36-41.

KEY WORDS: millimeter-wave radiation, power beaming, UAV, micro-AV

N99-153 TITLE: Sneak Circuit Analysis for Software

SCIENCE/TECHNOLOGY AREA: Computer Sciences, Computers, Software

OBJECTIVE: To eliminate unintended operational errors, states, or modes of corruption by finding problems related to current design processes that do not follow a top down hierarchical flow down process. And to use design models that are limited to the major aspects of the system design without concern for unintended paths or cross-linkages either introduced by process and environmental requirements or by implementation details from components whose capabilities are not required by the current design model(s).

DESCRIPTION: In hardware design during the design process, performance and other design requirements drive the design development in a top down fashion. If the design processes were simply a tree structure, though, this type of process would simply involve deductive methods and traceability would allow a logical evaluation of consistency. The design process, however, involves other cross pollination types of requirements which lead to alternate paths or relationships. In addition in hardware, there are real world and real object characteristics that are carried along which are not included in the detailed hardware models used for design. Because of the cross pollination of requirements and the fact that real object detailed interactions are not evaluated because the design process focuses on good object, model, and performance issues, undesired interactions are possible which can cause unwanted performance impacts, especially in the failure area, that designers are not aware of because of the limitations of the design models and because the flow down process focuses only on good system performance. Sneak circuit analysis was designed to look at some of the undesirable or safety related unwanted side effects from such a design process. Software has similar cross pollination and limited models focus in the design process, especially in the reuse of software, which can cause similar undesirable and destructive paths leading to unknown modes and states relationships that need further analysis like a sneak circuit analysis for software. This research project is to define the types of design process and model limitations that lead to sneak paths in systems and software and to develop design processes, techniques, and tools to evaluate the effects of these unintended operational characteristics.

PHASE I: Research the system and software design process for a domain used for integrated platform combat systems or joint warfare coordination systems to investigate the cross pollination aspects, effect of limited modeling of system or software details, and the focus of design on good performance without addressing the implementation related side effects. Examine areas where system and software design can introduce these undesirable and unwanted side effects. Examine the major problems which are found in the implementation area since the implementation of the requirements is the most important area for evaluation of alternate paths, states, and unwanted modes of operation. Provide a report that documents the results of this investigation.

PHASE II: Develop procedures and processes which eliminate the source(s) of error or which allow the designer to find such types of errors in system or software design process(es) or models. Apply these new processes and techniques to a combat system or coordination system component(s) and provide a report on the results.

PHASE III: Take the results from Phases I and II and extend design processes using COTS to commercial systems.

COMMERCIAL POTENTIAL: Unintended paths and undesirable modes and states from these paths may be a major problem in commercial systems and COTS designs. The results of this research will raise the level of reliability and readiness of commercial system and make them more usable in defense systems.

KEY WORDS: Sneak paths; unintended operation; modes; states; system; software

N99-154 TITLE: Acoustic Technology Enhancement for 3" Countermeasures (CM).

OBJECTIVE: Analyze and develop an approach to replace current 3" CM electronic package with state of the art programmable processing technology in a 3" form factor for potential adaptive CM application.

DESCRIPTION: The Navy is interested in cost effective application of programmable/reprogrammable technologies that can be adapted for use in current and future 3" CM applications to mobile devices. Programmability envisioned is to be provided through a download link or as a reaction to receipt of signal of interest by the device itself. The new electronics when inserted in the device must be able to survive the current environmental conditions experienced during launch of the devices from Navy platforms.

PHASE I: Develop an approach to provide for a programmable form fit factor electronics board replacement of that contained in 3"CM with mobile capability. Identify and analyze current technologies that can provide current 3"CM with a direct replacement of electronics board with an electronics board containing processor(s), memory, and interface that permits reprogramming of device by the user, or as a result of acoustic emissions received. Acoustic technologies that can support the future establishment of a reactive capability are desirable and feasibility in the current 3" form factor should be identified.

PHASE II: Develop the performance, product integration requirements and design for fabrication and demonstration of Phase II programmable electronic board prototypes. Demonstrate design and integration compatibility of the prototype in a 3" mobile CM device. Complete the specification, design, and documentation for integration into a mobile 3"CM production devices to be provided under the Phase III project. Identify and analyze methods for incorporating reactive capability into mobile 3" CM devices. Develop Preliminary Engineering Change Proposal (PECP) for incorporation of reactive capability in future 3" CM devices.

PHASE III: Fabricate production models for technical and operational demonstration testing, including launch/deployment survivability, endurance and effectiveness in training and tactical environments. A final product specification shall be developed and delivered for initial production of an acoustically reactive mobile 3" CM device.

COMMERCIAL POTENTIAL: The programmable mobile 3" CM device has surface and subsurface application potential in Naval torpedo defense endeavors. The core programmable acoustic technologies resulting from this project have potential commercial application for maritime and various ocean systems including commercial fishing and remote operated vehicles. Adaptive acoustics may be applied as a relay for underwater communications or transmissions as well as off-shore oil and shipwreck explorations.

KEY WORDS: Acoustics, underwater, adaptive, echo repeat, countermeasure

N99-155 TITLE: Fiber Optic Depth Sensor for Towed Array Applications

SCIENCE/TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop a passive fiber optic depth (pressure) sensor capability for towed array applications.

DESCRIPTION: The Navy is developing low cost passive optical acoustic sensor technology for use in future Navy towed arrays. To utilize these sensors in tactical arrays, a passive fiber optic depth (pressure) sensor is required, which has the following performance characteristics: 0 to 1000 psi absolute full scale pressure range; 0.001 psi max threshold; 2500 psia (for 1 hour) survival pressure; -2oC to +40oC operating temperature; -28oC to +65oC storage temperature. The pressure sensor will be ported out of the next assembly (the hose) and must sense the ambient hydrostatic pressure external to the hose. A co-located temperature sensing capability may be necessary to correct the pressure sensor data over some portions of its operating range. The sensor will operate in an ISOPAR L environment and should fit within a cylinder 0.76 inches in diameter and 4 inches long. The fiber optic pressure sensor should operate without requiring electrical power at the sensor element. It must be capable of passive optical interrogation over a fiber optic link up to 3 km in length. Additionally, the sensor approach must be capable of multiplexing such that at least 12 of these sensors may be interrogated over a single pair of single mode optical fibers. Interrogation of the 12 sensors over a single (single mode) optical fiber would be preferred.

PHASE I: Develop a prototype fiber optic pressure sensor which will meet the above performance and optical

specifications. This prototype sensor may be a laboratory breadboard; however, the design must clearly be capable of meeting the mechanical and environmental requirements.

PHASE II: Develop and test a fully functional fiber optic pressure sensor. Deliver two individual sensors to the Navy for preliminary tow testing.

PHASE III: Produce pressure sensor suites for incorporation into military and civilian towed arrays.

COMMERCIAL POTENTIAL: These pressure sensors could be applied in any environment, which required the detection sensitivities described above. A passive fiber optic interrogation capability and the multiplexing of multiple sensors are needed in a number of EMI sensitive military and commercial applications.

REFERENCE: D. M. Dagenais and F. Bucholtz, Fiber-Optic Pressure Sensor Conceptual Study, Naval Research Laboratory Memorandum Report NRL/MR/5603--98-8104, March 31, 1998.

KEY WORDS: Pressure, depth, fiber-optic, sensors, towed arrays, multiplexing

N99-156 TITLE: Fiber Optic Rotary Joint

SCIENCE/TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop a hybrid fiber optic/electronic rotary joint capability for a variety of Navy applications.

DESCRIPTION: The Navy is developing low cost passive optical acoustic sensor technology for use in future Navy towed arrays. To deploy these arrays from tactical platforms, a hybrid fiber optic/electronic rotary joint is required with the following capabilities/characteristics: at least 8 optical single mode fibers; 1530-1565 nm optical wavelength; 2.0 dB max optical loss per fiber; - 60 dB max optical back reflection per fiber; at least 2 electrical conductors; compatible with triaxial and coaxial cables having a 53 + 3 ohm characteristic impedance; 500 Vdc operating voltage; 2.0 amps operating current; 0.2 ohms max DC resistance; 0-30 MHz operating frequency range. The rotary joint shall perform in both static and rotating conditions (>300 rotations @ 30 rpm) during periods of continuous seawater immersion and periods of intermittent seawater immersion/air exposure. Finished housing dimensions must fit within a cylinder 5 inches in diameter and 8 inches long.

PHASE I: Develop a prototype hybrid fiber optic/electrical rotary joint which will meet the above performance and mechanical specifications. This prototype rotary joint may be a laboratory breadboard; however, the design must clearly be capable of meeting the dimensional and environmental requirements.

PHASE II: Develop and test a fully functional hybrid fiber optic/electrical rotary joint. Deliver one individual hybrid rotary joint to the Navy for preliminary tow testing.

PHASE III: Produce hybrid fiber optic/electrical rotary joints for incorporation into military and civilian towed arrays.

COMMERCIAL POTENTIAL: These hybrid fiber optic/electrical rotary joints could be applied in any environment that required passing optical and electronic signals through a rotating device. Hybrid electronic and fiber optic interrogation capability is needed in a number of military and commercial applications.

KEY WORDS: Slip ring, rotary joint, fiber-optic, towed arrays, hybrid fiber optic/electrical, acoustic arrays

N99-157 TITLE: Development of Low Cost COTS Technology for Total Ship Monitoring

SCIENCE/TECHNOLOGY AREA: Computers

OBJECTIVE: Develop a low cost total ship monitoring system to estimate acoustic radiation signature and to determine on board machinery condition.

DESCRIPTION: An important design consideration in the development of new naval ships is reduced detectability by threat sensors, including radar, ESM, infrared, and acoustics. The design and operational condition of propulsion and auxiliary machinery largely determine the acoustic visibility to a hostile ship. Existing systems are installed on some Navy ships to monitor acoustic radiation. These systems have been effective but have used customized sensors, transmission networks and processors. Many recent commercial technology improvements appear able to contribute to implementation and improvement of this monitoring capability. The Navy seeks feasibility demonstration of low cost commercial technology (sensors, signal conversion, interfaces, networking, and processing) which can provide TSM capability with minimal reliance on custom components. The system would provide two main functions: a far field estimate of the sonar vulnerability based on current ship vibration data, and a machinery monitoring capability for detecting equipment degradation. It would also be beneficial to exploit the extensive data bandwidth and processing capabilities of modern COTS equipment to provide significantly improved information about monitored components. Commercial processors may be able to exploit recent processing advances in machinery condition analysis that can help to reduce preventive maintenance or reduce shipboard manning. Offerors should provide a detailed system concept, identification of key components, proposed processing approach, and a plan for a portable, scalable software architecture. The architecture should utilize open industry standards to the extent possible with a feasible technology migration path. A prototype or other demonstration of the proposed architecture is required.

PHASE I: Develop a detailed monitoring system architecture including a cost and technical tradeoff of key components. The architecture should, to the maximun extebt possible use Open System Architecture Standards and COTS hardware. Provide a processing design description and preliminary computer sizing & timing analysis. Provide an analysis of total cost of ownership including procurement and Life Cycle Cost.

PHASE II: Build a prototype TSM system, based on the Phase I architecture, that demonstrates the architectural viability, including signal conversion transmission, data acquisition and signal processing. Demonstrate critical elements of the proposed design including data collection/acquisition, processing and timing.

PHASE III: Develop and install a prototype system, based on the Phase II prototype, which provides full system functionality. Install the prototype system on a vessel selected by the Navy. Collect data and analyze TSMS performance and report results. Develop system specifications and documentation and transition system to a production program. Potential transition programs include SSN Backfit (ARCI), Trident noise M Monitoring System, NSSN and SEAWOLF.

COMMERCIAL POTENTIAL: Real-time machinery monitoring has a huge potential commercial market. Many industries monitor machinery over very long duration with infrequent "signature samplings". Real-time monitoring helps to reduce repair cost by helping to identifying failing components long before costly catastrophic failures occur. Example industries include the automobile industry, steel manufacturing, appliance industry, and many others.

REFERENCES:

1. Rohrbaugh, R.A. "Advanced Time-Frequency Analysis: Theory and Application to Machinery Condition Assessment" Naval Surface Warfare Center Carderock Division, SADP-U93/00039-715 1 April 1993.

2. Forrester, B., "Time-Frequency Analysis in Machine Fault Detection," in Time-Frequency Signal Analysis: Methods and Application, B. Boashash (ed.), John Wiley and Sons, New York, 1992.

KEY WORDS: COTS; Low Cost; Real-time Processing; Machinery monitoring; Transient monitoring; Preventive maintenance

N99-158 TITLE: UUV Metal-Seawater Energy Source

SCIENCE/TECHNOLOGY AREA: Surface / Undersurface Vehicles

OBJECTIVE: Develop and demonstrate an SSN-compatible advanced metal-seawater electrochemical energy source for future Unmanned Undersea Vehicles (UUVs) having an energy density over 500 Whr/kg over a power density range of 1 to 100 W/kg.

DESCRIPTION: UUVs operate in the unique undersea environment. The use of sea-water as one of the reactants in the generation of electric or electrochemical energy enables high energy densities by eliminating the need to carry 100% of the consumable materials. The goal of this effort is to develop a metal-seawater cell energy source to meet the broad range of UUV power needs.

PHASE I: Identify and develop novel metal-sea-water electrochemical energy source(s). Fabricate lab-scale hardware and

conduct a lab-scale tests to determonstrate feasibility and to define potential operating parameters for UUV operation. The development effort should quantify the potential performance payoff (energy density, power density) of the energy source by a combination of analysis and laboratory tests and provide experimental and analytical basis for further development in Phase II.

PHASE II. Phase I results must support a reasonable technical risk approach to meet a system energy density goal of over 500 Whr/kg over a power density range of 1 to 100 w/kg. A notional development plan for Phase II and beyond should be defined in Phase I.

PHASE II: Implement results and recommendations of Phase I analysis and test into scaled-up demonstration of the energy source at UUV operating parameters. Conduct further lab tests using Phase I test apparatus to define more optimun cell operating characteristics. Design, fabricate and demonstrate full-scale energy module operation (energy modules, cell stacks, subsystems) at UUV operating points(TBD). Demonstrate sub-scale or full-scale energy system operation, and pilot-scale manufacturing capability for UUV-unique energy system components.

PHASE III: Demonstration of energy source design and operation, and manufacturing processeses of critical UUV energy source components or elements will transition to the Government and acquisition program contractors. Mission Reconfigurable UUV (MRUUV) is the primary Navy program transition target.

COMMERCIAL POTENTIAL: The energy source technology has potential to greatly increase the commercial exploration of the oceans using autonomous vehicles (deep submersibles, ocean salvage, scientific exploration).

REFERENCES:

1.Enhanced Electrochemical Performance in the Development of the Aluminum-Hydrogen Peroxide Semi-Fuel Cell. E. Dow, et. al. Journal of Power Sources, 65 (1997)

2. A Solution Phase Catholyte Semi-Fuel Cell utilizing a Flowing Aqueous Electrolyte, 193rd Electrochemical Society Meeting, San Diego, May 3-8 1998, Dow and Medeiros.

3. U.S. Patent #5,718,986 (980217), ACells with a battery positive of hypochlorite or chlorite ion and anodes of magnesium or aluminum, Abner Brenner

KEY WORDS: undersea vehicles; UUV energy source; water-breathing propulsion; underwater propulsion; magnesium; sea-water batteries

BUREAU OF NAVAL PERSONNEL

N99-159 TITLE: Standardized Internet-Based Multimedia/Virtual Environment (MM/VE) Survey Interface

OBJECTIVE: To develop, test, and field a complete internet-based multimedia/virtual environment (MM/VE) survey system that uses a standardized intuitive human-computer interface.

DESCRIPTION: Survey technology is well developed for paper-and-pencil methods, however, survey administration by this traditional method is resulting in an increasingly low rate of return. Personnel may be inundated with multiple, time-consuming survey requests from which they receive little feedback. In addition, written questions alone may be ambiguous or subject to multiple interpretations despite careful pilot testing. Finally, paper-and-pencil surveys can ask a limited variety of question types. Internet technologies, including hypertext markup language (HTML) and virtual reality modeling language (VRML), and internet animation and graphics software, make new kinds of questions possible. These new question types hold the promise of engaging the participant while collecting new types of information. To capitalize on the promise of a marriage of these technologies with survey technologies, a simple standardized interface is required. Ideally, this interface will be incorporated into a survey software system that has, at a minimum, the additional security and tabulation features of the better survey software systems on the market today.

PHASE I: Design and perform a feasibility study exploring possible options and techniques for creating a standardized, intuitive human-computer interface for internet-based MM/VE surveys. The interface should anticipate the addition of new types of technologies. These should be incorporated as work progresses.

PHASE II: Develop a standardized human-computer interface for internet-based MM/VE surveys. Evaluate the ease of use and utility of the interface through testing with human subjects. Refine the interface and design and perform a preliminary test of the interface in a survey setting. Test the system both for functionality in a scientific survey and for intuitive user utilization.

Design and perform a feasibility study for incorporating the interface into a survey software system.

PHASE III: Develop and test a prototype survey software system that incorporates the standardized human-computer interface developed and tested in Phase II. Produce and field a complete, upgradable, internet-based MM/VE survey system suitable for civilian as well as military use.

COMMERCIAL POTENTIAL: Surveys are an important descriptive research tool for the social sciences. As such, surveys are conducted both the military and civilian sectors. This technology will permit the scientific administration of new types of questions that can optimize the full potential of the internet.

REFERENCES: Sample U.S. Navy technical reports of recent organizational surveys can be provided upon request.

1. Earnshaw, R., & Vince, J. (Eds.) 1997. The internet in 3D: Information, images and interaction. San Diego, CA: Academic Press.
2. Norusis, M. J. (1997). SPSS 7.5 guide to data analysis. Upper Saddle River, NJ: Prentice Hall.
3. O'Rourke, D. (Ed.). (1992). Questionnaire formatting and demographic questions: Samples of questionnaires from academic/government survey organizations. Urbana, IL: Survey Research Laboratory, University of Illinois.
4. Rosenfeld, P., Edwards, J. E., Thomas, M. D. (Eds.) (1993). Improving organizational surveys. Newbury Park, CA: Sage Publications.
4. Sudman, S. (1976). Applied sampling. New York, NY: Academic Press.

KEY WORDS: interface; internet; multimedia; personnel; survey; virtual

N99-160 TITLE: Access Control and Personnel ID Verification for Training Applications Utilizing Smart Cards

OBJECTIVE: To develop Smart card technology that will provide id verification and access control to applications used in training environments.

DESCRIPTION: Smart Card technology provides a solution to a growing problem in the training industry. Situations exist where widely dispersed training audiences (particularly for WAN based applications) require various levels of access control to training materials. The use of a Smart card as a security access/user identity verification key provides an avenue to deliver distance learning applications in the right amount, to the right people. The Smart card provides a multitude of other benefits as well. These benefits could include access control to exercises based on proficiency ratings and certification for the completion of any prerequisites, as well as a vehicle to store student course transcripts. It could allow control of access based on personal data (such as rank/rate). The Smart card provides a means of physical control for access, making hacking impossible, since authentication is done at the card level and not through a centralized on-line system. With the addition of user identity verification, the card could be used as a key to activate the correct security levels as well. Smart Cards are currently used to provide easy control of encrypted files and Internet e-mail requiring physical control of the decryption mechanism.

PHASE I: Review the current Department of Navy uses for the Smart Card and determine what access controls are needed for current Navy training programs and future Advanced Distributed Learning programs.

PHASE II: Identify a Naval training program with access control and verification requirements. Design a multi-level security access and user identity verification system. Conduct feasibility study on the identified Naval training by implementing and testing Smart Card based access controls.

PHASE III: Pursue commercial application of products in industries requiring higher levels of security, such as the banking industry, university and college systems, Information Technology controlled products, and other access controlled environments.

COMMERCIAL POTENTIAL: Smart Card technology has tremendous potential in the commercial industry. Multi-level access control could be used as a key to internet authorization, bank-teller access, automatic check cashing machines, carrying updated medical information with limited access controls, university student id cards, etc.

KEY WORDS: Smart Card, Distance Learning, Access Control, Authentication

STRATEGIC SYSTEMS PROGRAM OFFICE

N99-161 TITLE: Low-Cost Fabrication of Multi-Use 3-D Carbon-Carbon Composites

SCIENCE/TECHNOLOGY AREA: Materials and Structures, Aerospace Vehicles

OBJECTIVE: Identify and demonstrate manufacturing technologies which reduce fabrication times and costs for 3-D carbon-carbon (C-C) composites.

DESCRIPTION: Current 3-dimensional (3-D) carbon-carbon (C-C) production processes are time consuming and costly (exceeding $1000/pound), limiting the usefulness of this material in many potential applications. An alternate, shorter time and lower cost *(ie., $100/pound goal)* fabrication process is desired. Minimum C-C property requirements are provided in Reference 1, p. 199. The alternate production process must be able to produce uniform density C-C in a size of at least 6 x 6 x 10 inches. In addition to the ability to produce C-C materials meeting minimum property requirements, it is desired that the alternate process be capable of producing higher strength C-C. Thus, a flexible fabrication process is desired which can provide higher, or lower, performance C-C materials at corresponding costs and fabrication times.

PHASE I: Develop a flexible production process for, and produce small quantities of, a C-C material. Obtain preliminary mechanical and thermal properties for the material to confirm meeting minimum property requirements (full characterization can extend into the phase II). Provide a cost comparison for the new vice existing fabrication process. Provide a detailed discussion/plan to show how the new fabrication process is sufficiently flexible to produce higher/lower capability 3-D C-C materials at commensurate cost and fabrication time.

PHASE II: Fabricate and characterize (mechanical and thermal properties) a range of C-C materials. The performance range of materials produced shall include military grade equivalent material. The material cost versus performance relationship shall be documented.

PHASE III: As needed, additional C-C materials shall be produced to complete the performance versus cost database.

COMMERCIAL POTENTIAL: Carbon-carbon materials are severely limited in market applications due to high cost. The current program would identify processing approaches to significantly reduce C-C cost to enable commercial product insertion. Commercial products include self-lubricating, high-temperature components (such as automotive pistons), human body implants, corrosion-resistant components for the chemical industry, and replacement of high strength graphite.

REFERENCES: *Buckley, J.D., et al.,* Carbon-Carbon Materials and Composites, *NASA Reference Publication 1254, February 1992.*

KEY WORDS: carbon-carbon composites, carbon fibers, weaving, braiding, pre-form construction, carbon-carbon composite processing.

NAVAL SUPPLY SYSTEMS COMMAND

N99-162 TITLE: Environmentally-Safe, Marine Disposable Gun Plugs

SCIENCE/TECHNOLOGY AREA: Material and Structures

OBJECTIVE: The purpose of this work is to develop and demonstrate gun plugs that can be safely disposed of in marine environments in accordance with MARPOL Treaty requirements and in land environments.

DESCRIPTION: Military operations require the use of gun plugs which function as a seal of the carriage case mouth in 5"/54 (and others) propelling charges. The plug also acts as a buffer for packing the projectile with propelling charge in the gun mount. The current materials used are 52% toluene diisocyanate (TDI) and 48% polyurethane resin. The current gun plug has the following specifications; but not limited to: Density 17 – 19.5 pounds per cubic foot. Compressive Strength mean greater than 500 psi with no value less than 425 psI. Shelf Life 20+ years in sealed magazine. Thermal Expansion_Not more than .03% at 50°C after 24 hours. Voids Internal and external none greater than .125 inch length and .063 depth. Tensile Strength_mean greater than 375 psi with

no less than 300 psi.

PHASE I: In Phase I, the contractor will demonstrate that gun plug can be fabricated from combinations of natural materials that will quickly break down and which are environmentally-safe.

PHASE II: In Phase II, refine materials formulations and processing techniques so that test quantities of gun plugs can be fabricated. The contractor will subject the gun plugs to degradation testing. The contractor will also subject the gun plugs to laboratory and field testing to demonstrate that they can fulfill their intended purpose with all guns requiring such plug.

PHASE III: In Phase III, the contractor will work with industry to transition the products to the commercial marketplace, if applicable.

REFERENCES: Environmentally-Safe; Degradable; Gun Plug; Toluene Diisocyanate; polyurethane resin; Density.

N99-163 TITLE: Lightweight Firefighter's Boots Employing Modern Materials and Manufacturing Techniques

SCIENCE /TECHNOLOGY AREA: Materials/Manufacturing

OBJECTIVE: Develop a fire fighter's boot which will be significantly lighter in weight than the existing boot through the use of modern materials and manufacturing techniques. The resulting boot will improve fire fighter mobility and safety while reducing fatigue and improving mission effectiveness.

DESCRIPTION: The fire fighting boot used by the Navy at shoreside locations, training facilities and for damage control missions onboard ship is of the extremely bulky, heavy rubber variety worn by municipalities and volunteer fire departments. These firefighter boots are manually produced by building up many layers of die cut rubber on top of cushioning materials, such as felt, foamed rubber or fabric. Once the proper number of layers has been sandwiched and the sole applied, the boot is subjected to a heating process to bond the components together. Representative boots and manufacturers of the type described above are :

Firebreaker	Fire Tech	Flameguard
Norcross Safety Products	LaCrosse Footwear, Inc	Lehigh Safety Shoe Co.
Rock Island, Illinois	LaCrosse, Wisconsin	Endicott, New York
(309) 786-7741	(608) 782-3020	(800) 444-4354

The opportunity exists to replace this type of boot with a new and lighter design by leveraging more modern materials and production techniques widely available to the domestic boot industry. A basic approach might include the use of lightweight thermally stable plastics coupled with injection molding. It is envisioned that a weight reduction of at least 30% could be realized along with a 25% decrease in cost. The potential benefits for an improved fire fighter's boot are tremendous since this technological advancement would be enthusiastically received nationally by all fire fighting organizations, which in turn would further reduce cost. Since injection molding is prevalent in this country, competition to produce the boot would be increased resulting in an additional cost reduction.

PHASE I: Identification and selection of light weight materials and composites capable of meeting established National Fire Protection Association standards when incorporated into a fire fighter's boot. Fabrication of first generation prototype boots to demonstrate cost effective manufacturing techniques suitable for preliminary laboratory testing against governing standards. Multiple concepts are encouraged to explore various approaches.

PHASE II: Refinement of prototype concepts and the manufacture of limited test quantities for multi-service user assessment.

PHASE III: Transition successful concept to production and commercial application.

COMMERCIAL POTENTIAL: The commercial potential for a fire fighter's boot exhibiting a significant reduction in weight would be enormous since it would be embraced by fire fighters in both large municipalities as well as local volunteer fire departments. The benefit of this technological advancement would positively impact all fire fighters especially when a cost reduction is envisioned.

REFERENCES: National Fire Protection Association Standard for Protective Ensembles for Structural Fire Fighting (NFPA 1971)

KEY WORDS: Light Weight, Composites, Injection Molding, Flame Retardant, Fire Fighting, Protective Clothing

SPACE AND NAVAL WARFARE SYSTEMS COMMAND

N99-164 TITLE: RF Bandpass Filters

OBJECTIVE: To provide miniaturized high rejection RF bandpass filters.

DESCRIPTION: Current RF bandpass filters do not provide enough rejection in the frequency ranges above 1 GHz. New bandpass filters are required for these higher frequency ranges.

PHASE I: Design a high rejection RF bandpass filter, with a brick wall type of performance. Low insertion loss, significantly lower than 10 dB is desired. The dimensions of the filter should not exceed 1.5 cm in any direction . RF filters than can be built using monolithic substrate technology is desired to keep productin costs low. Model and simulate its performance. Prepare a technical report.

PHASE II: Build the high rejection RF bandpass filter designed in Phase I. Test the filter on a Government furnished antenna at a government laboratory. Prepare a report of the test results.

PHASE III: Install the high rejection RF bandpass filter on submarine antenna system. Perform Sea Trial testing. Prepare a report of results, and recommendations to improve performance.

COMMERCIAL POTENTIAL: Commercial satellite communication antenna systems.

KEY WORDS: RF, filters, antennas, SATCOM, UHF, RADAR

N99-165 TITLE: High Quality, Low Data Rate (LDR) Secure Voice

SCIENCE/TECHNOLOGY AREA: C3

OBJECTIVES: Provide high quality intelligible digitized secure voice at low data rate in Link 16 environment and in Link 16 platforms.

DESCRIPTION: Link 16 supports two secure voice circuits, each with 127 sub circuits. There are two principal Link 16 terminals: Joint Tactical Information Distribution System and Multi-Function Information Distribution System.

Each JTIDS terminal contains two 16 Kilobits voice encoders. At 8Khz sampling rate, these analogs to digital converter provide "voice recognition" quality communications. Unlike data in Link 16, the present digitized voice is not Reed-Solomon error encoded. Without Reed-Solomon, transmission errors are not corrected prior to conversion to audio or prior to retransmission for relay. Practical experience indicates that 16Kbps voice is understandable with up to 10% of bits in errors (Bit-Error-Rate BER= 10%). When operating in jamming or in low signal-to-noise ratio environment (Link 16 environments) relayed voice will become unusable first, followed by garbled direct voice, and unrecoverable data.

The next generation of the Link 16 terminal is the MIDS. MIDS voice capability is capable of implementing both 2.4KBPS and 16KBPS rates. With each of the implementation, there are selectable choice of Voice data rates (2.4, 4.8, 9.6, or 16), Error correction coding option (encoded or non-encoded), Message Packing limit and Time Slot assignment. With the 16KBPS selection, the MIDS will operate the voice channel as non-error coded and employs the continuous variable slope delta (CVSD). With the 2.4KBPS, the MIDS implement the National Security Agency (NSA) Linear Predictive Coding (LPC-10) (sampling rate of 8Khz). The current MIDS system segment specification calls for up to 5% BER. The probability of achieving a false correlation (on four consecutive synchronization pattern frame) is no less than 0.999. With this current implementation and if operate in the jamming environment where BER could be up to 10%, this implementation is not likely to achieve intelligent voice.

Currently in 1996, the Department of Defense Digital Voice Processor Consortium just named the Mixed-Excitation Linear Predictive Vocoder (MELP) as the new 2400 bits-per-second (bps) Vocoder Federal Standard. The MELP vocoder compresses the bit stream to 2400 bps, a significant 25:1 reduetion. This voice may be acceptable in the laboratory where the jamming is unrealistic, however, in the Link 16 environment where jamming could potentially induced more than 10% BER (low signal-to-noise ratio) in addition to the ambient noise. In the MELP, the voiced portions of the bit stream have no error correction, but the unvoiced portions have forward error correction. The error correction cannot be removed. Without additional error correction, any errors will degrade the quality somewhat. Bit errors become intrusive over about 2%. Burst errors become intrusive at about 4%. If there is some sort

of channel error indication, the burst errors become intrusive at about 10-15%, depending on the statistics of the bursts. At 10% BER, the voice become unintelligent. The additional protection scheme is needed to the MELP to handle up to 10% bit errors and more than 20% burst errors (without channel error indication). Even with breakthrough in this research, the approved MELP is only handling the peacetime environment where signal to noise ration is low and jamming is unlikely. Therefore, the MELP is an unlikely candidate for the jamming and in low signal-to-noise ratio (high BER) for the DoD Link 16.

PHASE I: Develop an advanced secure low bit rate and high BER tolerance (10% or more) speech coding algorithm that could reconstruct intelligent Link 16 voice. The algorithm should include the evaluation, examination, and comparison of alternative of existing potential algorithms such as MELP and Code Excited Linear Predictive Coder (CELP). The algorithm must be portable into existing structure of the JTIDS and MIDS with minimal impact. The Mean Opinion Score (MOS) score must be at least 3.3 or better (higher).

PHASE II: Implement and test the algorithm in a Link 16 operational environment.

PHASE III: Develop a transition plan for integration into the JTIDS, MIDS, and future Link 16 terminal.

COMMERCIAL POTENTIAL: There are numerous commercial applications ranging from aircraft to highway vehicles.

KEY WORDS: Anti-Jamming, Low Bit Rate, Speech Coding, Secure Voice, Link 16, High BER, Secure Voice.

N99-166 TITLE: Miniature Antennas For Submarine Advanced Buoyant Cable Systems

OBJECTIVE: Develop miniature RF antennas that can be located in a small surface towed module that is part of a buoyant cable antenna system which is deployed and retrieved from a submerged submarine. These secondary payloads will augment the operation utility of the module and fit within the residual payload envelope.

DESCRIPTION: Submarines currently use buoyant cable antenna system to provide limited RF communications capabilities while at operating at various speeds and depths. This effort will develop the size, shape, and performance of antenna concepts that could be part of the buoyant cable system to add capability. The antennas can be located either within or deployed and retrieved from a small buoyant module located at the end of the buoyant cable. The antennas must be small and operate over a seawater ground plane in low and high sea states. Antennas can address frequency bands within the following areas; RF (UHF-EHF transceive), ESM (2-40 GHZ receive), and Navigation (GPS receive). This effort would establish antenna concepts, size, shape and RF performance through analysis, scale models and testing. Evolving commercial telecommunication satellite system requiring very small antenna systems, such as Iridium and Teledesic are potential future communication links.

PHASE I: Identify miniature antenna concepts that can provide installed in a buoyant cable system and provide RF capability. Conduct analysis to establish antenna shapes, sizes, and RF performance.

PHASE II: Develop full size models of selected antennas and conduct laboratory RF tests to validate analysis performed in Phase I.

PHASE III: Develop full size model of selected antennas and conduct tow testing of antennas to establish RF and hydrodynamic performance characteristics.

COMMERCIAL POTENTIAL: Evolving commercial telecommunications, telemetry and navigation satellite systems are targeting handheld, portable, and mobile mounted connectivity applications at rates up to and beyond T1. Antennas developed to link to these systems for a buoyant cable antenna module have potential for transition into compact consumer products.

REFERENCES: ONR technical reports/briefings on 6.2 effort for the Low Profile Antenna and DARPA technical reports/briefings for the Buoyant Cable Antenna Array. Iridium worldwide phone/paging system, INMARSAT C paging and Global Positioning System are candidate systems.

KEY WORDS: Antennas; Miniature; RF; Submarine; Analysis; Models

N99-167 TITLE: Intelligent Agent Security Module

OBJECTIVE: Develop an intelligent module to allow interoperation with Automated Auditing Tools, Intrusion Detection Systems, firewalls and other NVI security solutions.

DESCRIPTION: Investigate COTS products for real-time automated auditing collection and reduction and for real time intrusion detection collection and interpretation. Based on the limitations of available technologies, develop an intelligent agent module to utilize current and future automated collection and reduction tools and to utilize current and future intrusion detection collection and interpretation tools. The intelligent agent module will integrate inputs from audit reduction, intrusion detection and all other security functions using an adaptive wrapper scheme to communicate with the intelligent agent. The inputs will be utilized to develop user profiles and compare system usage against prescribed NVI policies to automatically identify potential threats to information systems. The nature of the information collected and presented by this intelligent agent security module will lend itself to system administrator functions well beyond security. Besides overall workload reduction for the system administrator, the agent will be able to assist in functional areas such as Configuration Management and Asset Allocation.

PHASE I: Develop adaptable wrappers to allow COTS products to interact with intelligent agent. Develop intelligent agent structure for use in development in Phase II.
Investigate existing technologies suitable for application in an intelligent agent security module and identify policies and user profile parameters. Perform laboratory demonstration of developed adaptable wrappers at small business location. Utilize Phase I option of additional funds to provide a demonstration of communications with COTS products via use of developed adaptable wrappers in a government facility to be identified.

PHASE II: Develop the intelligent agent security module. Integrate the adaptable wrappers/COTS demonstration from Phase I with the intelligent agent and demonstrate the full capability of the intelligent agent security module in a testbed facility to be designated by the government.

PHASE III: Contingent upon a successful demonstration in Phase II, develop the intelligent agent security module in a form factor suitable for integration with the NVI initiative and for marketing as a potential commercial product.

COMMERCIAL POTENTIAL: Corporations are aggressively pursuing solutions to reduce security vulnerabilities associated with their information network systems and provide automated intelligent assistance to their system administrators. Automating technologies and intelligent agent modules as described above would have direct and immediate application in commercial environments.

KEY WORDS: intelligent agents, intrusion detection, audit reduction, firewall, Network Operation Center, security vulnerabilities, COTS products

N99-168 TITLE: Optimal Integration of Multi-functional Information Distribution System (MIDS), Inertial Navigation Systems (INS), and Global Positioning System (GPS)

OBJECTIVE: Optimize the availability of GPS quality position, velocity and time information for use in a host of electromagnetic environments and to provide a secure link for precision aircraft landing.

DESCRIPTION: Commercial and military applications are increasing reliance on GPS to provide accurate position, velocity and time measurements to meet operational requirements. The FAA has approved the use of GPS for en-route navigation and the military and civil users are considering using GPS for precision aircraft landing. As applications that use GPS increase in complexity, the vulnerabilities of GPS become significant. This effort would use existing technology and information available in MIDS, INSs and GPS to provide a robust/optimal secure position, velocity and time source to meet the needs of the military user in a hostile electromagnetic environment foremost and the civil/military user in precision aircraft landing.

PHASE I Establish requirements and design an optimal (sub-optimal) external Kalman Filter that combines raw measurements from MIDS, INS and GPS. Develop an applique to transmit this AGPS Quality position, velocity and time information to a user who requires GPS accuracy. Examine the feasibility, utility, and effectiveness of the filter and transmission vehicle. Prepare concept of operations and analysis of alternatives paper addressing civilian and military utility.

PHASE II: Apply the results of Phase I to develop and test a proof-of concept prototype low cost MIDS Applique

Receptor. Validate the effectiveness of the concept.

PHASE III: Apply the results of Phase I and II to produce and integrate the AGPS Quality Applique in a full scale operational environment.

COMMERCIAL POTENTIAL: This system will provide an effective and secure source of GPS quality position, velocity, and time information for precision landings of civilian and military aircraft.

REFERENCES:

1. GPS/JTIDS/INS Integration Study Final Report, Draper Laboratory, June '78;
2. Decentralized Relative Navigation and JTIDS/GPS/INS Integrated Navigation Systems, Widnall et al, MIT, January '82

KEY WORDS: MIDS; JTIDS; GPS; INS, Navigation, Positioning, Fix Taking

N99-169 TITLE: Distributed Inertial Sensor Tactical Navigation Tool (DISTANT)

OBJECTIVE: Develop an inertial navigation system augmentation employing spatially distributed sensors in combination with advanced computational techniques.

DESCRIPTION: With the latest advancement in accelerometer technology (including micro-electromechanical accelerometer technology), reliable, small-sized and low-cost accelerometers are readily available. In contrast, small size, low-cost gyros have yet to demonstrate inertial navigation grade performance. The availability of multiple distributed accelerometers will allow construction of improved navigation systems.

PHASE I: Establish requirement and conduct initial analysis of improvements to be expected in gyro accuracy using spatially distributed low cost accelerometers to enhance gyro accuracy. The analysis should examine enhancements to be gained using multiple accelerometers in some optimally distributed configuration in selected Naval platforms to provide improved INS performance. The number of accelerometers, geometrical configurations, and computational techniques shall be studied. Design a prototype inertial navigation system.

PHASE II: Apply results of Phase I, perform computer simulations to bound the performance characteristics of the prototype configurations. Evaluate available low-cost inertial sensors, which can support selected configurations. Develop a prototype for a selected Navy platform as recommended in Phase I. Conduct concept demonstration and testing in a laboratory and on an operational Naval vessel.

PHASE III: Apply the results of Phase I and II to produce and integrate the navigation tool into an operational system.

COMMERCIAL POTENTIAL: Applicable to various commercial applications where GPS navigation is used; e.g., Satellites, commercial space lift vehicles, commercial aircraft, etc.

KEY WORDS: Distributed; Inertial; Sensors; GPS; Navigation; Accelerometers; Gyroscope

N99-170 TITLE: Interactive Human Systems Interfaces and 3D tools for Information Warfare Systems

SCIENCE/TECHNOLOGY AREA: Computers, Software

OBJECTIVE: To develop a set of 3D tools that will provide an innovative user interface for effective use of information. This information is typically collected by a sensor and analysis system and provided to a command and control infrastructure for information or action.

DESCRIPTION: Although communications intercept systems can provide battlespace information, the user interfaces on most of these systems primarily support collection and analysis of various type of signals intelligence. To be useful as weapons in the command and control infrastructure, these information collection systems must support a different set of functions and must provide effective interfaces for information weapons systems. Functions include: 1) IFF and target selection; 2) easily understandable

representation of the current battlefield situation (e.g. damage assessment), and 3) decision support in a rapidly changing and complex environment. The user interface must both optimize IW mission effectiveness and be consistent with integrated C4ISR and combat systems under the various DII COE (Defense Information Infrastructure Common Operating Environment) standards. The current DII COE standards build primarily on commercial 2D applications. In line with the overall Joint Technical Architecture (JTA) and the DII COE, several programs and R&D initiatives are generating 3D type applications. In addition, the need to prevent user interface problems for IW and other applications highlights the need for Navy 3D Tactical Data Symbology. These developments could be expanded to a 3D Joint Mapping toolkit as part of a consolidated set of 3D libraries. The set of 3D libraries, specific to DOD mission critical applications, could complement current commercial libraries. These sets of 3D tool kits could also minimize duplication of development and reduce overall DOD 3D visual software development cost.

PHASE I: Investigate current commercial packages to be leveraged to support various standard operating environments such as UNIX, NT, and Java. Design and prototype an innovative battlefield visualization and decision support interface for Information Warfare Systems.

PHASE II: Design, develop and evaluate a user interface, based on the technology used in Phase I, that can be incorporated into an existing Information Warfare system. The system should be evaluated for efficacy, ease of use, and compatibility with the underlying Information Warfare System. Apply the results of Phase I to develop beta libraries. Distribute to select list of DII COE development community for feedback and assess supportability.

PHASE III: Applying the results of Phase I and II, produce an initial release library package and provide it to DISA DII COE for implementation and release to the DII COE development community. Host the prototype interface system and tool set to participate in a full up field evaluation.

COMMERCIAL POTENTIAL: Similar interfaces and 3 D tool sets will be required by numerous agencies (Coast Guard, major city police headquarters operations, counter-narcotic operations, other government agencies) operating sensor and information Command Centers. These 3-D tool sets will also have widespread application for operations and maintenance of advanced wireless telecommunications networks to identify network vulnerability and intrusion detection.

REFERENCES: DD-21 Opsits, DD-21 Mission Needs Statement

KEY WORDS: Information warfare; decision support; data visualizations; command and control infrastructure; software libraries, 3 dimensional, METOC, Displays, C^4ISR, DII COE

N99-171 TITLE: Near Real Time Modeling of Cable and Sensor Orientation on the Ocean Floor after Near Bottom Installation

OBJECTIVE: Develop efficient and reliable real time algorithms for determining the as-deployed location of fiber-optic micro-cable(s).

DESCRIPTION: With the increasing use of fiber-optic micro-cables by the U.S. Navy, an accurate real time determination of where these cables have landed on the sea floor is required. Future undersea surveillance fiber-optic micro-cables and acoustic arrays will be deployed from an underwater towed vehicle operating near the ocean floor. The knowledge and understanding of the geographical position, line-of-bearing accuracy and straightness of the arrays after they are laid is critical to their performance in detecting and tracking targets. The physical ocean environment and positions of the deployment vehicles during the installation process determine the final placement of the cables and arrays. The current profile that exists between the deployment point and ocean floor will affect the bottom location and shape (slack) of arrays and cable. The bathymetry of the ocean also affects how the cable will be laid on the sea floor. Therefore, the operator of the underwater vehicle continuously evaluates the current profile, ship's speed, bathymetry and other sensor inputs. Effective adjustments in the underwater vehicle depth, tow speed, and heading could be made to eliminate or reduce undesirable current effects if the effects could be assessed in real time.

Current program(s) can provide non-real time estimates of cable/array shape on the bottom. The software now in use (ATrac-Time Domain Response Analysis of Cables or FOCAL-P) requires extensive off-line post-processing to provide estimates of cable posture on the bottom. Additionally, it relies on fixed, manual parameter inputs. This is clearly not adequate for the deployment of fiber-optic micro-cable from surface and subsurface vehicles

PHASE I: Determine the feasibility, establish requirements, define concept, and develop preliminary designs for a real

time algorithm for submerged fiber-optic micro cables locating. Conduct analysis of existing submerged cable locating algorithms and models to better understand their ability to meet the established requirements. This analysis should include verification of accuracy; development of interfaces for the automatic, real time input of variables such as cable parameters, bathymetry, ship and underwater vehicle position, underwater vehicle depth, and current profile; and optimization of the model to run efficiently and in real time.

PHASE II: Develop a proof-of-concept algorithm to run on various platforms. Test the proof of concept against the requirements established in Phase I in the operational environment to include participation in at sea optimization of the micro-cable installations.

PHASE III: Apply results of Phase I and II to produce a reliable real time algorithm for operational undersea fiber-optic micro-cable locating. Integrate the capability into deployed control and monitoring equipment used to deploy surface and sub-surface fiber-optic micro-cables.

COMMERCIAL POTENTIAL: These improved algorithms could be applied to commercial programs that install submarine cables that require real time assessment of where the cable(s) has been laid. This is particularly applicable to the commercial telecommunications industry and another industry where undersea optical cables may be deployed.

KEY WORDS: Fiber-optic; micro-cable; installation, computer, current; undersea locating

N99-172 TITLE: Secure Voice Over Wide Area Networks

SCIENCE/TECHNOLOGY AREA: Command, Control, & Communications

OBJECTIVE: Enable secure voice communications over Internet Protocol (IP) and asynchronous transfer mode (ATM) networks, including networks over satellites and other radio frequency (RF) links. Provide full 2-way dialog for unicast and multicast modes

DESCRIPTION: Past secure voice communications have used dedicated circuits. The military is now transforming these dedicated circuits into IP-based networks, allowing many functions to share the same network capabilities. Certain high-bandwidth circuits will use ATM technology, with the IP network sharing the ATM network with other communication forms. Although these new communication technologies are essential to accommodate the anticipated growth of military needs, they must be implemented in a way that is transparent to the users. Some users need to talk person-to-person (unicast mode) while others need to communicate to many users over a common network (multicast mode). The Navy, in particular, is dependent on networks that use RF links. These RF links are subject to bandwidth constraints and circuit noise. The solution must take these factors into account.

PHASE I: Develop a detailed system architecture that meets the objective needs of the military. This entails the identification and development of technology that performs the security functions, and may include the ordering and distribution of supporting key material, over the relatively narrow band radio frequency connections available to Navy units.

PHASE II: Develop and demonstrate the system over Navy Wide Area Networks. This requires the development, integration, implementation and demonstration of the architecture described in the first phase. Included are the development of the implementing products for the voice communications security functionality (including the speech digitization and the security algorithm), the network controlling elements (to guarantee the real time nature of secure voice), and the key management and distribution elements. It is desired that the implementation be demonstrated to be interoperable with existing secure voice systems, such as STU-III, ANDVT, KY-57/58, etc.

PHASE III: Contingent on a successful demonstration, develop and produce the next-generation Navy secure voice over networks system. The production system must be made easy to use, easy to maintain, and supportable in a military environment. The production system will be used in the Automated Data Network System (ADNS) and the Base Level Information Infrastructure (BLII) if successful.

COMMERCIAL POTENTIAL: While commercial products have demonstrated voice transmission over Internet Protocol networks, none of these products are secure. Both the secure encoding and the call establishment must be made in real time. It is known that establishing a secure voice connection over Navy wide area networks is non-trivial. Although there may be commercial products embedded in the final solution, the system itself will entail substantial development in order to be workable. No commercial items exist that do all of the functions known to be needed, nor are the products that do small pieces of the required functionality

sufficiently compatible to be integrated directly. For example the required one-to-many mode of operation is particularly challenging as none of the commercial items directly respond to this requirement. Formulating the detailed system architecture will require substantial research and development effort to define a workable system design having the needed security attributes.

DUAL USE: The application of this system capability for commercial requirements is potentially large. Industry is already investing in commercial intranets to integrate and maintain their information infrastructures. Although military level security is not necessarily needed, a high degree of privacy is required to protect their proprietary advantage in the market. Like so many things in the security area, items developed with military use in mind are desired in the commercial market. Although a separate key management infrastructure will be required, and potentially some encryption algorithms may need to be protected or restricted, the technology developed will in general be directly transferable to commercial sector use.

KEY WORDS: secure voice; voice over IP; voice over ATM; voice over data networks; satellite communications;

N99-173 TITLE: Cryptologic Component Architecture

SCIENCE/TECHNOLOGY AREA: Computers, Software

OBJECTIVE: Provide a new and innovative ultra high speed digital processing server for use with an array of integrated IO-Exploit, IO-Attack and IO-Defend software client components.

DESCRIPTION: Over the past few years, costs and schedules for development, testing, maintenance, and training have increased significantly, while the Navy's R&D budget has declined. The proposed technology will provide better ways to develop these Information Warfare systems, reduce costs, and provide increased flexibility for the user. This technology will produce a substantial reduction in technology transition time and life cycle costs. The architecture shall demonstrate sufficient flexibility to meet the broad needs of existing applications and to grow as needed to support new requirements.

PHASE I: The Phase I investigation will develop approaches that consider capacity and throughput requirements for existing and planned applications, their underlying components, and component commonality within and across Navy Information Warfare systems. The contractor will investigate various standards and develop an approach utilizing those enabling standards considering key throughput performance requirements, capacity flexibility, and the potential use of NDI products. The report of the Phase I effort should include a well defined and justified approach for developing a suitable digital processing engine that is capable of sustaining the real time throughput and capacities required for the Joint Maritime Information Operations System (JMIOS).

PHASE II: During Phase II, the contractor will produce a common baseline prototype of digital processing components and clearly defined APIs using the proposed architecture of phase I and demonstrate their integration into a COBLU or JMIOS. The developed architecture will be evaluated for its ability to implement common software processes and products. The contractor will refine key performance parameters, provide a complete set of components, associated documentation and training materials consistent with best commercial practices.

PHASE III: Team with a manufacturer or supplier to transfer and fully integrate the design into the JMIOS design, development and production.

KEY WORDS: JMIOS, Information Operations, Software, Object-Oriented Design, and Digital Processing Componentware.

AIR FORCE
PROPOSAL PREPARATION INSTRUCTIONS

The responsibility for the implementation and management of the Air Force SBIR Program is with the Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio. The Air Force SBIR Program Executive is R. Jill Dickman, (800) 222-0336. **DO NOT** submit SBIR proposals to the AF SBIR Program Executive under any circumstances. Addresses for proposal submission and numbers for administrative and contracting questions are listed on the following pages, AF-2 through 4.

Technical questions may be requested using the DTIC SBIR Interactive Technical Information System (SITIS). For a full description of this system and other technical information assistance available from DTIC, please refer to section 7.1 of this solicitation.

Air Force Nine-Month Phase I Contract

For the Air Force, the contractual period of performance for Phase I shall be nine (9) months, and the price shall not exceed $100,000. No proposal with a contractual period of performance less than nine (9) months shall be considered.

The primary research must be accomplished during the first six months of the contract. The price of the primary research in the first six months will not exceed $80,000. It is the bulk of the research for the Phase I effort. The primary research effort, alone, is used to determine whether the AF will request a Phase II proposal. The proposal, alone, including Fast Track applications, shall decide who will be selected for Phase II. Our evaluation of the primary research effort and the proposal will be based on the factors listed in section 4 of the solicitation, in the following descending order of importance: a) the soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution; b) the qualifications of the proposed principal/key investigators, supporting staff, and consultants (qualifications include not only the ability to perform the research and development but also the ability to commercialize the results) and c) the potential for commercial (government or private sector) application and the benefits expected to accrue from this commercialization. The actual assigned weightings will not be disclosed outside of the DoD. It is noted that where technical evaluations are essentially equal in merit, and as cost and/or price is a substantial factor, cost to the government will be considered in determining the successful offeror.

Phase II proposals are by invitation only. (All Fast Track applicants will be invited.) If requested, the Phase II proposal must be submitted within six months from the start of Phase I to ensure that the proposal will be evaluated and is eligible for award. After the first six months, additional related research must be conducted that furthers the Phase I effort and puts the small business in a better position to start Phase II, if awarded. The last three months of the nine-month technical effort will not be considered in the evaluation process leading to Phase II awards.

The last three months of the nine-month Phase I contract will provide project continuity for all Air Force Phase II award winners so no modification to the Phase I contract should be necessary. The Air Force will accept proposals for modifications to maintain project continuity under special circumstances such as Fast Track.

Commercial Potential Evidence

A Phase I or II proposal's commercial potential can be evidenced as follows: 1) the small business concern's record of commercializing SBIR or other research, particularly as reflected in its Company Commercialization Report (Appendix E); 2) the existence of second phase funding commitments from private sector or non-SBIR funding sources; 3) the existence of third phase follow-on commitments for the subject of the research and 4) the presence of other indicators of commercial potential of the idea, including the small business' commercialization strategy.

Air Force Cost Proposal

The Air Force anticipates that pricing of this action will be based on adequate price competition. Proposals, including costs, are limited to 25 pages. However, if you are selected to receive an award, be prepared to submit further documentation to substantiate costs in the event that it is either subsequently determined that adequate price competition does not exist or that further information is necessary to facilitate the contracting process.

Air Force Fast Track

Detailed instructions on the Air Force Fast Track and Phase II proposals consistent with this solicitation will be made available by the awarding Air Force activity at the time of Phase I contract award.

PROPOSAL SUBMISSION INSTRUCTIONS

For each Phase I proposal, send one original and four (4) copies to the office designated below. Be advised that any overnight delivery may not reach the appropriate desk within one day. Be sure to read the Air Force instructions on the previous page for the nine-month Phase I contract to avoid the rejection of your proposal. To request notification of proposal receipt, send request (Ref A on page Ref 1) with a self-addressed stamped envelope. Do not call to ask whether your proposal has been received; due to time constraints, we will not be able to answer such telephone calls.

TOPIC NUMBER	ACTIVITY/MAILING ADDRESS (Name and number for mailing proposals and for administrative questions)	CONTRACTING AUTHORITY (For contract questions only)
AF99-001 thru AF99-026	Directed Energy Directorate AFRL/DE 3550 Aberdeen Ave SE, Bldg 497, Rm 239 Kirtland AFB NM 87117-5776 (Robert Hancock, (505) 846-4418)	Sam Berdin (505) 846-1097
AF99-029 thru AF99-079 and AF99-331 -- *EXCEPT for the six topics listed immediately below*	Space Vehicles Directorate AFRL/VS 3550 Aberdeen Ave SE, Bldg 497, Rm 239 Kirtland AFB NM 87117-5776 (Robert Hancock, (505) 846-4418)	Francisco Tapia (505) 846-5021
AF99-033, AF99-040, AF99-053, AF99-067, AF99-069, AF99-073	Space Vehicles Directorate AFRL/VSOT Bldg. 1107, Room 242 29 Randolph Road Hanscom AFB, MA 01731-3010 (Noreen Dimond, (781) 377-3608)	John Flaherty (781) 377-2529
AF99-082 thru AF99-104	Human Effectiveness Directorate AFRL/HE 2509 Kennedy Circle, Rm 161 Brooks AFB TX 78235-5118 (Belva Williams, (210) 536-5429)	Don Norville (210) 536-6393
AF99-107 thru AF99-144	Information Directorate AFRL/IF 26 Electronic Parkway Rome NY 13441-4514 (Jan Norelli, (315) 330-3311)	Joetta Bernhard (315) 330-2308
AF99-145 thru AF99-178	Materials & Manufacturing Directorate AFRL/MLOP 2977 P St, Rm 418, Ste 13, Bldg 653 Wright-Patterson AFB OH 45433-7746 (Sharon Starr, (937) 656-9221)	Terry Rogers (937) 255-5830 Bruce Miller (937) 255-7143
AF99-179 thru AF99-197	Munitions Directorate AFRL/MNOB 101 W Eglin Blvd, Ste 140 Eglin AFB FL 32542-6810 (Richard Bixby, (850) 882-8591x1281)	Lorna Tedder (850) 882-4294 x3399

AF99-205 thru AF99-230-- *EXCEPT for the 9 topic listed immediately below*	Propulsion Directorate AFRL/PROP 1950 Fifth St, Bldg 18 Wright-Patterson AFB OH 45433-7251 (Dottie Zobrist, (937) 255-6024)	Terry Rogers (937) 255-5830 Bruce Miller (937) 255-7143
AF99-204, AF99-211 thru AF99-216, AF99-218, and AF99-219	Propulsion Directorate AFRL/PROP (Sandi Borowiak) 5 Pollux Drive Edwards AFB, CA 93524-7033 (Sandi Borowiak, (805) 275-5617)	Donna L. Thomason (805) 277-3900 X2277
AF99-235 thru AF99-263	Sensors Directorate AFRL/SNOX 2241 Avionics Cir. Rm N2S24, Bldg 620 Wright-Patterson AFB OH 45433-7320 (Marleen Fannin, (937) 255-5285x4117)	Terry Rogers (937) 255-5830 Bruce Miller (937) 255-7143
AF99-265 thru AF99-280	Air Vehicles Directorate AFRL/VAOP 2130 Eighth St, Suite 1 Bldg 45, Rm 219 Wright-Patterson AFB OH 45433-7542 (Madie Tillman, (937) 255-5066)	Douglas Harris (937) 255-4427
AF99-284 thru AF99-292	Warner Robins ALC WR-ALC / TIECT 420 Second Street, Suite 100 Robins AFB GA 31098-1640 (Cpt. Bill Braasch, (912) 926-6617)	Cheryl Ficklin (912) 926-9086
AF99-293 thru AF99-299 AF99-307 AF99-324 AF99-326	Air Armament Center AAC/XPP 101 W. D Avenue, Suite 129 Eglin AFB FL 32542-5495 (Dave Uhrig, (850) 882-8096)	Lt. Tim Scarborough (850) 882-8567
AF99-300 thru AF99-306 AF99-325 AF99-330	Air Force Flight Test Center AFFTC / XPST 195 East Popson Avenue Edwards AFB CA 93524-6843 (Abe Atachbarian, (805) 275-9266)	Donna Thomason (805) 277-3900 x2277
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46TG/XPX, HOLLOMAN AFB NM

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OKLAHOMA CITY ALC, TINKER AFB OK

AF99-323	IDEF3 Based Training

Department of the Air Force
FY1999 SBIR Topic Descriptions

AF99-001 TITLE: Adaptive Optics Wavefront Compensation Algorithms

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Demonstrate innovative concepts for precise compensation of optical waveforms through turbulent media and from aircraft platforms.

DESCRIPTION: Innovative concepts leading to advanced capabilities in the area of adaptive optics are solicited. These approaches could be useful to programs, such as the Airborne Laser, that require adaptive optics compensation for laser propagation through the atmosphere. The intent is to improve the performance of airborne beam control missions by conceiving and demonstrating innovative concepts for precise compensation of optical waveforms through turbulent media, and from moving platforms looking at moving targets. Innovation is needed in wavefront reconstruction and high frame rate control with the goal of optimizing strehl at the target after propagation through long horizontal paths in an atmosphere with saturated scintillation. Concepts that combine aspects of higher order wavefront compensation with low order tilt compensation will also be considered.

PHASE I: Design innovative adaptive optics approaches and demonstrate that such approaches are feasible for meeting advanced Air Force requirements. Demonstrate the feasibility of producing a demonstration of the adaptive optics concepts, and outline a sound set of demonstration success criteria. Design reviews will cover the individual components, the demonstration architecture, and the control concepts.

PHASE II: Demonstrate the enhanced adaptive optics capabilities based on the approach developed in Phase I. The proposed demonstration can be either ground-based (such as at the Air Force Research Laboratory's Airborne Laser Advanced Concepts Testbed at White Sands Missile Range) or airborne, but in either case should include the effects of both atmospheric turbulence and platform motion.

PHASE III DUAL USE APPLICATIONS: It is expected that an adaptive subsystem based on the concepts proposed under this research, with economical considerations folded in, would have both commercial and military applications. The military applications include all those with requirements for precise atmospheric compensation through turbulent media and from moving platforms to moving targets. The commercial market includes such areas as astronomy, communication, power beaming, and surveying. It is expected that the contractor will concentrate on flexible Phase I designs to maximize commercialization potential.

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1. Robert K. Tyson and Peter B. Ulrich, "Adaptive Optics", in The Infrared and Electro-Optical Systems Handbook Volume 8, Environmental Research Institute of Michigan, Ann Arbor MI, 1993.
2. Paul H. Merritt et al., Active tracking of a ballistic missile in the boost phase, in SPIE Proceedings Vol. 2739, Acquisition, Tracking, and Pointing, pp.19-29 (1996).
3. Daniel H. Leslie and Douglas G. Youmans, Atmospheric effects on eye-safe airborne laser radar, in SPIE Proceedings Vol. 2375, Beam Control, Diagnostics, Standards, and Propagation, pp.17-29 (1995).
4. Bea et al., Flexible beam expanders with adaptive optics: a challenge for modern beam delivery, in SPIE Proceedings Vol. 2375, Beam Control, Diagnostics, Standards, and Propagation, pp.84-95 (1995).

KEYWORDS: scintillation, anisoplanatism, adaptive optics, wavefront sensor, deformable mirror, optical turbulence

AF99-002 TITLE: High-Power Laser for Long-Range Ranging Applications

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Develop a modular, scalable laser architecture capable of producing greater than 10 kW of average power when fully scaled.

DESCRIPTION: Systems that use lasers to make measurements at long ranges require lasers with high-average power (>10 kW), good beam quality (M2 < 3), and pulsed operation at repetition rates from 2 to 10 kHz. Due to system power constraints, relatively high efficiency laser technology is required. Many of these applications require field use of the laser systems, so laser systems with relatively small volumes and which can be robustly packaged are desired. Additionally, it is desirable to be able to operate for extended periods of time with minimal use of consumable materials (such as liquids or gasses), so closed-cycle systems are preferred.

These many conflicting requirements make it difficult to produce a single system simultaneously satisfying all requirements. Rather than producing a single laser oscillator capable of meeting these system requirements, it may be simpler to combine the optical output of a smaller number of laser "modules" to meet the requirements. An example of such a technology is the master oscillator/power amplifier system described in the literature. A scalable architecture using smaller laser modules is the desired result of this solicitation. Any solutions capable of meeting the specifications will be considered. Such an architecture, if it can be developed, can then be tailored to meet the needs of several different applications without having to redevelop the entire technology base.

PHASE I: Produce a conceptual design of both the laser modules and the scaled system, and analyze the predicted performance and identification of technological risk areas. Laboratory demonstration of the crucial technical concepts and risk areas is desirable and will be a factor in award selection.

PHASE II: Produce and test breadboard laser modules and use them to demonstrate scalability in the laboratory. Combine the laser modules to produce a higher-power laser suitable for field testing.

PHASE III DUAL USE APPLICATIONS: A high-powered, scalable laser technology would be extremely useful to many customers within DoD, including Airborne Laser, Ground-based Laser, and Space-Object imaging efforts within Air Force Space Command. Additionally, a scalable laser architecture could be used to satisfy other DoD and commercial applications with different power requirements. Following successful Phase II demonstrations of the laser modules and scaling techniques, a Phase III program may be initiated to produce a hardened laser capable of being integrated into field experiments. Potential commercial applications would be the industrial manufacturing base where high-power lasers currently are used; the end result of this project could be an industrial laser with higher beam quality than is currently available.

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KEYWORDS: power amplifier, laser technology, phase conjugation, phase combination, master oscillator, near-infrared lasers

AF99-003 TITLE: Aircraft Electromagnetic Interference Diagnostic and Fault Location System

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Develop an integrated system capable of identifying internal sources of electromagnetic interference and locating faults within complex electronic systems onboard aircraft.

DESCRIPTION: New generations of aircraft are highly dependent on complex electronic systems to provide not only critical flight functions, but also to perform a multitude of mission functions. Digital electronics are being exploited to provide "glass cockpit" and mission displays combined with fly-by-wire, information processing, and automated control functions to a degree never seen before. This dependence on digital electronics combined with higher clock rates, power conserving signal levels, increased use of composite materials, onboard radar, communications transmitters, and lasers, increases the chances of Electromagnetic Interference (EMI). Current instrumentation used to identify and locate EMI problems has not kept pace with the development of these highly complex systems. Present methods and instrumentation used in EMI tests can be time consuming, labor intensive, intrusive, and difficult, especially for intermittent problems, in a highly automated aircraft with extensive electronic systems.
There is a need for an integrated system with multiple EMI sensors that can be distributed throughout an aircraft and are capable of gathering time and phase correlated data and analyzing the results to determine the sources of EMI and their individual effects on the electronics. Requirements such as these demand integration of the sensors into standard electronics printed architecture. This will allow instrumentation modules to be installed within existing electronics enclosures for the purpose of collecting and processing signals without altering the system electromagnetic characteristics. These instrumentation modules should be capable of interfacing with the electronics back plane and connectors with the characteristic impedance, should emulate board communications functions, and should capture and digitize coupled transients. Individual miniaturized instrumentation modules are also desired for test points that are external to electronic enclosures. This system should also have the capability to generate EMI fields or cable currents that emulate those measured during system level tests to allow testing to be conducted without the need to operate radar, other transmitters or EMI sources to improve safety and efficiency of testing. The integrated diagnostic and fault location system should be highly automated to speed test and keep the number of test personnel to a minimum. The system should also be capable of producing standardized test reports and other documentation with a minimum of individual effort. This approach will reduce costs, speed development time, and allow critical support resources to be conserved.

PHASE I: Analyze potential concepts and perform critical experiments to demonstrate the feasibility of an approach to meet the objectives outlined above. Document the results of these efforts in a report. The report shall also include possible Phase II partnering and an approach for commercialization.

PHASE II: Develop a working prototype system for performing EMI testing of aircraft (large & small) with additional mission electronics and emitters on board. Demonstrate this system on an existing aircraft and compare the results with current EMI testing methods.

PHASE III DUAL USE APPLICATIONS: The EMI test system should be applicable to large and small military and commercial aircraft. Military versions of the system may require special packaging. The system should be easy to use and include testing procedures unique to the system. Self test capabilities should be included along with calibration methods. The system should be automated to produce the final test report with a minimum of operator input.

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2. Cornet,M.G., Adaptive EMI Reduction for Future Naval ESM Systems
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KEYWORDS: fault, sensors, aircraft, hardening, diagnostics, radio frequency, instrumentation, electromagnetic interference (EMI)

AF99-004 TITLE: Tracking through Optical Turbulence

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Demonstrate innovative concepts for tracking laser beacons through optical turbulence where strong scintillation is present.

DESCRIPTION: Innovative concepts leading to advanced capabilities in the area of pointing and tracking are solicited. These approaches could be useful to programs, such as the Airborne Laser, that require precise tracking of laser beacons through optical turbulence where strong scintillation is present. The intent is to conceive and demonstrate innovative concepts for precise stabilization of optical waveforms through turbulent media in order to improve the performance of airborne pointing and tracking missions. We are looking for innovative approaches that more effectively use the information that is available, or where minor hardware changes give significantly improved performance. These approaches can include, but are not limited to: use of multiple apertures, multiple beacons, Kalman filter or other estimators, or transform methods.

PHASE I: Design innovative pointing and tracking approaches and demonstrate that such approaches are feasible for meeting advanced Air Force requirements. Design reviews will cover the individual components, the demonstration architecture, demonstration success criteria, and the control concepts.

PHASE II: Demonstrate the enhanced pointing and tracking capabilities based on the approach developed in Phase I. The proposed demonstration can be either ground-based (such as at the Air Force Research Laboratory's Airborne Laser Advanced Concepts Testbed at White Sands Missile Range) or airborne, but in either case should include the effects of both atmospheric turbulence and platform vibration. It is expected that this phase will provide valuable lessons learned for an Air Force system with requirements for precise pointing and tracking, so that transition is made easily to systems such as the Airborne Laser.

PHASE III DUAL USE APPLICATIONS: It is expected that a pointing and tracking subsystem based on the concepts proposed under this research, with economical considerations folded in, would have both commercial and military applications. The military applications include all those with requirements for precise pointing and tracking through turbulent media and from vibrating platforms, including Airborne Laser, Infrared Countermeasures (IRCM) programs, and directed energy point defense programs such as the Tactical High Energy Laser (THEL). The commercial market includes such areas as laser communication, power beaming, and surveying. It is expected that the contractor will concentrate on flexible Phase I designs to maximize commercialization potential.

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1. Paul H. Merritt et al., Active tracking of a ballistic missile in the boost phase, in SPIE Proceedings Vol. 2739, Acquisition, Tracking, and Pointing, pp.19-29 (1996).
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5. Bea et al., Flexible beam expanders with adaptive optics: a challenge for modern beam delivery, in SPIE Proceedings Vol. 2375, Beam Control, Diagnostics, Standards, and Propagation, pp.84-95 (1995).

KEYWORDS: tilt, tracking, pointing, scintillation, laser propagation, optical turbulence

AF99-005 TITLE: Energy Donor for Iodine Atom Transfer Laser

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Develop improved singlet delta oxygen generation techniques and/or new energy donor molecules to pump ground state iodine to the electronic excited state.

DESCRIPTION: Singlet delta oxygen is currently used as the energy donor molecule for the Chemical Oxygen Iodine Laser (COIL) device. The singlet delta oxygen generation process involves two-phase gas/liquid chemistry where gaseous chlorine is brought into contact with a liquid electrolyte solution of Basic Hydrogen Peroxide(BHP). The two major drawbacks to this approach are the production of water vapor (which deactivates excited state iodine) and the weight penalty associated with the water in the electrolyte BHP. Obvious approaches to dealing with water production (i.e. use of colder BHP temperature/use of deuterated BHP) have been investigated and found to have problems of their own. The Air Force Research Laboratory (AFRL) is seeking alternate ways of producing singlet delta oxygen at high pressure and high molar flow rates in a manner which has favorable weight scaling for Airborne Laser (ABL) or Space-Based Laser (SBL) applications. Alternately, there is interest in using other energy donors to pump the iodine atom to its excited state. One such approach, using singlet delta nitrogen chloride (NCL) as the donor, is under investigation at the AFRL.

PHASE I: Identify the concept and subscale proof-of-principle experiments. Investigate scaling potential to high flow rates with associated weight.

PHASE II: Develop generator hardware to interface with the RADICL device at the AFRL Phillips Site for testing with power extraction.

PHASE III DUAL USE APPLICATIONS: Commercial applications of COIL technology include industrial strength welding and cutting. This technology would also improve COIL performance for both ABL and SBL applications.

REFERENCES:
1. Madden, T. J. and Solomon W. C., "A Detailed Comparison of a Computational Fluid Dynamic Simulation and a Laboratory Experiment for a COIL Laser," AIAA 96-2354, 28th AIAA Plasmadynamics and Lasers Conference, June 23-25, 1997, Atlanta, GA.
2. Zagidulin, M. V., Nikolaev, V. D., Svistun, M. I., Khvatov, N. A., and Ufimtsev, N. I., "Highly efficient supersonic chemical oxygen-iodine laser with a chlorine flow rate of 10 mmol s-1," Quantum Electronics, 27, (3), pp. 195-199, (1997).

KEYWORDS: energy donor, gas phase energy donor, energy transfer species, metastable energy donors, metastable energy carrier, chemical laser energy donor

AF99-006 TITLE: Non-Evasive In Situ Cable Shielding Tester

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop the capability to allow the electromagnetic shielding properties of aircraft shielded cables to be measured without disconnecting any of the cable connectors or removing the cable from the aircraft.

DESCRIPTION: Testing of aircraft shielded cables requires that one connector of a cable be disconnected or the entire cable removed from the aircraft to measure the electromagnetic shielding properties. This practice is time consuming, costly, and can cause damage to the cable and other components during the process. Commercial aircraft must undergo a re-certification of the cable after it has been disconnected and reinstalled. The goal of this effort is to develop a test capability that will allow the shielding properties of installed cables to be measured without disconnecting any of the cable connectors or removal from the aircraft. The frequencies of interest for this test capability extend from 10 kHz to 500 mHz. The tester must be easily portable and user friendly with minimum operator skills needed to determine pass/fail of the cable shielding.

PHASE I: Perform experiments to determine and demonstrate an approach which can be developed into a prototype system during a Phase II effort that meets the objectives outlined above. Document the approach and information developed during this phase in a report. The report shall also include possible Phase II partners and a commercialization approach.

PHASE II: Develop a working prototype test system and demonstrate its capabilities on one or more aircraft. Self test and built-in calibration capabilities shall be included as appropriate. A means of logging results for later transfer to a central automated data base is also desirable.

PHASE III DUAL USE APPLICATIONS: The shielded cable tester should be useful for either military or commercial aircraft. Different versions of the tester may be needed to meet military handling requirements versus those needed for commercial operations. The system should be easy to use, include testing procedures, and have a self test capability.

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1. Michael M. Marino, Dr. Parviz Parhami, Built-In Test For Electromagnetic Shielding Program. PL-TR-97-1054, March 1997.
2. Damaskos, N., Kelsall, B., Passive Shielding for Low Frequency Magnetic Fields, 1997.
3. Coonrod,K., Davis, S., McLemore, D. Fault Detection Techniques for Complex Shield Topologies, 1994.
4. Blocher, T., Validation of Shielding Effectiveness of Cables with Pigtails.

KEYWORDS: cable, fault, sensors, aircraft, hardening, shielding, diagnostics, radio frequency, instrumentation, electromagnetic interference (EMI)

AF99-007 TITLE: Tracking/Wavefront Processor for High Bandwidth Control Applications

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Develop a processor architecture using COTS components that supports high bandwidth control applications.

DESCRIPTION: Advanced beam control systems like the Airborne Laser require high bandwidth control systems with closed loop bandwidths exceeding 1 kHz for control of various tracking loops and wavefront sensing loops. These control systems put a premium on processing in real time at high speeds and also require high-speed read/write memory. This effort will develop a processor architecture that will maximize the use of commercial off-the-shelf components (COTS) and will retain a degree of processor flexibility that will allow new algorithms for different tracking/wavefront control applications to be loaded easily without re-engineering/rebuilding the processor. The design must be able to meet the needs of both tracking and wavefront control applications, and must be flexible enough to add additional throughput/storage capability as needed. The goals for the processor are to support real time processing at 10 kHz frame rates for cameras with 256 x 256 pixels.

PHASE I: Produce a conceptual design for the processor, including architecture, interface definition, timing, data storage, and graphical user interface.

PHASE II: Design and produce a complete processor. This system will be tested with sample algorithms provided by the government, simulating a tracking control system.

PHASE III DUAL USE APPLICATIONS: This processor would be useful to both Airborne Laser and ground-based laser programs, as well as to astronomy applications within DoD and NASA. A processor of this type would be commercially useful in many imaging applications requiring high bandwidth and real time control, including process monitoring and control, high-speed photography, and remote sensing.

REFERENCES:

1. Robert K. Tyson and Peter B. Ulrich, "Adaptive Optics", in The Infrared and Electro-Optical Systems Handbook Volume 8, Environmental Research Institute of Michigan, Ann Arbor MI, 1993.
2. Paul H. Merritt et al., Active tracking of a ballistic missile in the boost phase, in SPIE Proceedings Vol. 2739, Acquisition, Tracking, and Pointing, pp.19-29 (1996).

KEYWORDS: tracking, processor, high-bandwidth, wavefront sensor, real-time control, high-frame rate cameras

AF99-008 TITLE: Advanced Chemical Oxygen-Iodine Laser (COIL) Mixing Nozzles

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Develop improved approaches for mixing and reacting iodine and singlet delta oxygen flows in COIL devices.

DESCRIPTION: The Air Force Research Laboratory at Kirtland AFB is seeking approaches for development of advanced chemical oxygen-iodine laser (COIL) mixing nozzle concepts. Successful approaches must demonstrate improved performance characteristics

over traditional COIL mixing nozzle concepts in one or all of the following aspects of COIL operation: mirror power lading, gain magnitude and distribution, chemical efficiency, and pressure recovery. Traditional COIL mixing nozzles inject molecular iodine/diluent mixtures into the subsonic region of the singlet delta oxygen flow upstream of the nozzle throat, often leading to gain distributions that heavily load the leading edge of the mirrors (see Reference 1). Studies (see Reference 2) suggest that one mechanism for alleviating this problem is to inject the molecular iodine/diluent mixture into the supersonic region of the singlet delta oxygen flow, thereby producing a slower gain increase that reduces the power loading on the mirrors. Variations on the supersonic mixing concept offer the possibility of improving the chemical efficiency and pressure recovery of COIL's. One such concept uses parallel mixing of supersonic molecular iodine/diluent and singlet delta oxygen/diluent flows, reducing total pressure loss over traditional transverse molecular iodine/diluent injection mechanisms and improving pressure recovery. Another concept mixes parallel supersonic singlet delta oxygen /diluent and F,HI(DI)/diluent flows. This concept offers the possibility of significantly improved chemical efficiency over traditional COIL devices by using F to produce I in the reaction F + HI (DI) results in HF (DF) + I, thereby eliminating the need to dissociate molecular iodine using singlet delta oxygen. Approaches incorporating some or all aspects of these various concepts are of strong interest to the Air Force in that lighter, more efficient COIL devices may result.

PHASE I: Analyze and develop various COIL mixing nozzle concepts. Concept feasibility should be demonstrated on the basis of mirror loading, gain distribution, chemical efficiency, and pressure recovery predicted by proven models.

PHASE II: Select, fabricate, and test selected concepts in experiments.

PHASE III DUAL USE APPLICATIONS: In addition to Air Force applications, the development of lighter weight and higher chemical efficiency COIL systems has direct pertinence to ongoing efforts to commercialize COIL's. This technology can potentially improve COIL performance for Air Force Airborne Laser applications. Commercial applications include industrial strength welding and cutting. Of particular relevance is the use of less expensive diluents, such as nitrogen, which decrease the cost of COIL operation.

REFERENCES:

1. Madden, T. J. and Solomon W. C., "A Detailed Comparison of a Computational Fluid Dynamic Simulation and a Laboratory Experiment for a COIL Laser," AIAA 96-2354, 28th AIAA Plasmadynamics and Lasers Conference, June 23-25, 1997, Atlanta, GA.
2. Zagidulin, M. V., Nikolaev, V. D., Svistun, M. I., Khvatov, N. A., and Ufimtsev, N. I., "Highly efficient supersonic chemical oxygen-iodine laser with a chlorine flow rate of 10 mmol s-1," Quantum Electronics, 27, (3), pp. 195-199, (1997).

KEYWORDS: COIL mixing, COIL nozzle, iodine mixing, secondary mixing, supersonic mixing, supersonic nozzle

AF99-009 TITLE: Lidar for Remote Sensing of Optical Turbulence

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop a lidar-based sensor to measure optical turbulence strength remotely.

DESCRIPTION: Systems that propagate lasers through the atmosphere, such as the Airborne Laser (ABL), are affected by the optical turbulence strength along the path. Currently, there are several optical techniques for measuring vertical profiles of the refractive index structure parameter (Eaton et al., 1988). There are also in situ techniques for obtaining refractive index structure parameter point measurements from probes mounted on aircraft, providing horizontal and slant path information. What is needed is a technique that can remotely obtain point measurements along a propagation path, such as what could be obtained with a lidar (see for example Chan and Killinger, 1992). A lidar operating from the aircraft platform could potentially obtain a three-dimensional map of refractive index structure parameter in the area of interest where the system must operate. Another advantage of a lidar technique is that it could also sense other parameters of interest including cirrus clouds. Innovative approaches to lidar for measuring refractive index structure parameter will be entertained that show promise for both surface and aircraft operation. The approach must exhibit the potential to operate in a "vibration" environment such as with an aircraft platform. Since many of the adaptive optics techniques that were developed by DoD have recently been declassified, many large astronomical observatories are actively pursuing the implementation of adaptive optics for mitigating turbulent effects of long exposure imagery obtained with the large astronomical telescopes. Once these adaptive optics systems are operational, it is highly probable that a lidar that senses refractive index structure parameter and other parameters, such as nighttime cloud conditions, would become a requirement.

PHASE I: Produce a conceptual design for the lidar. Also produce detailed analysis of the predicted performance (range, resolution, dynamic range). A laboratory proof of concept would be a plus, but is not required.

PHASE II: Develop a breadboard lidar system capable of being fielded at the Airborne Laser Advanced Concepts Testbed (ABL ACT) at White Sands Missile Range. This system would be used to obtain refractive index structure parameter profiles over a 51-km horizontal path.

PHASE III DUAL USE APPLICATIONS: Since many astronomical sites are initiating adaptive optics programs, it is likely that

a small commercial lidar system, that would provide profile information of refractive index structure parameter and sense thin clouds at night when clouds aren't visible, would also be attractive. A commercial lidar that is maintainable, dependable, and "user friendly" is essential for such operations. A lidar system to remotely measure optical turbulence would be extremely useful to many customers within DoD, including the Airborne Laser, Ground-based Laser, and Space-Object imaging efforts within the Air Force Space Command. Upon a successful Phase II test, it is very likely that a Phase III program would develop that would include integrating a flight-worthy system on board assets such as ARGUS to demonstrate lidar as a Tactical Decision Aid for the Airborne Laser.

REFERENCES:

1. Eaton, F. D., W. A. Peterson, J. R. Hines, K. R. Peterman, R. E. Good, R. R. Beland, and J. H. Brown, "Comparison of VHF Radar, Optical, and Temperature Fluctuation Measurements of refractive index structure parameter, r[subO], and [theta sub O]", Theor. and Applied Climatol., 39, 17-29 (1988).
2. Kin Pui Chan and Dennis K. Killinger, "Coherent 1 micron lidar measurements of atmospheric-turbulence-induced spatial decorrelation using a multi-element heterodyne detector array", Applied Optics, 31, 105, (1992).

KEYWORDS: lidar, cirrus clouds, laser propagation, optical turbulence, site characterization, refractive index structure parameter

AF99-010 TITLE: Acoustic Suppression for Precision Equipment in High-Performance Aircraft Interiors

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Develop a hardware system to compensate for the detrimental effects of multiple acoustic inputs originating both external and internal to the enclosed volume of an aircraft.

DESCRIPTION: Active noise control has advanced significantly in recent years, but most applications to date have addressed physical systems with relatively limited spatial or temporal complexity. For example, noise is reduced at a single headset location or only for small numbers of sources contributing narrowband or perhaps multi-tonal input. The F-16 aircraft and any use of High Energy Lasers (HEL) represent a highly complex acoustic environment that includes multiple noise sources outside and inside the aircraft and a large number of noise and vibration sensitive precision optical components. High sound pressure levels are potentially present over a broad frequency range, and performance requirements for jitter and alignment on F-16 aircraft are extremely demanding and are distributed over multiple components. Passive means of acoustic compensation are physically limited at low frequency and are not well suited to adapt to changes in the disturbance environment and performance demands during a typical mission. The project will employ advanced noise control techniques that can also be projected to practical automated implementation in an airborne environment with reasonable constraints on weight. The approach could include localized or distributed cancellation, equipment or machinery enclosures, feed-forward and feedback control, active-passive hybrid systems, and coupled vibro-acoustic considerations. The proposer should consider the differences between this development and development for noise suppression in commuter passenger aircraft and should understand the realistic limits of global broadband active noise control.

PHASE I: Demonstrate by analysis, and possibly through supporting test data, a cohesive approach to acoustic compensation for the interior of fighter aircraft with external and internal acoustic sources. Identify a critical high-payoff subsystem technology for further development.

PHASE II: Fabricate an acoustic compensation subsystem and demonstrate its ability to improve substantially the performance of a representative laboratory precision optical system under realistic acoustic amplitude input levels, frequency content, and time-variability. Demonstrate by high fidelity simulation the expected performance improvement for the aircraft environment and provide components for possible flight tests to be conducted by the Air Force.

PHASE III DUAL USE APPLICATIONS: Potential commercial applications include commercial aircraft and other vehicles, active enclosures for precision manufacturing and optical inspection equipment, and suppression of sound in high-density multi-purpose workspaces. Potential military applications include the HEL laser systems on fighter aircraft, other vehicles incorporating precision sensors and instruments, and compensation for reduced personnel fatigue.

REFERENCES:

1. B. Widrow and S. Stearns, "Adaptive Signal Processing," (Prentice-Hall, NY) 1985.
2. P. A. Nelson and S. J. Elliott, "Active Control of Sound," (Academic Press, NY) 1992.
3. S. M. Kuo and D. R. Morgan, "Active Noise Control Systems," (John Wiley & Sons, NY) 1996.

KEYWORDS: aircraft acoustics, high energy lasers, active noise control, high g-factor effects, interior optical disturbances, vibration control in moving aircraft

AF99-011 TITLE: Low-Noise, High-Bandwidth Cameras for Wavefront/Tracking Sensors

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop a low-noise SWIR camera for active tracking and wavefront sensing that operates at frame rates in excess of 5 kHz.

DESCRIPTION: Advanced beam control systems like Airborne Laser require high-bandwidth, low-noise cameras for tracking and wavefront sensing. The high bandwidth is required to collect information to feed high bandwidth control loops necessary to compensate for atmospheric effects such as optical turbulence. The noise levels affect the stability of these control loops and ultimately the range of the system. Lower noise performance allows for potential weight reduction on the aircraft due to a reduction in laser power necessary to achieve the designed range. Alternatively, lower camera noise can increase the system performance. The camera needs to operate in the Short Wavelength Infrared (SWIR) region, especially at laser wavelength in the range from 1.4 to 1.06 microns. The current state of the art for near infrared cameras in this wavelength range is video frame rates (60 Hz) with quantum efficiencies less than 10 percent and noise levels of 100 noise electrons per pixels. The goals for this program are frame rates in excess of 5 kHz, quantum efficiencies of better than 50 percent, and noise levels of less than 50 noise electrons per pixel.

PHASE I:Develop a conceptual design for a camera system to include focal plane array design, readout architecture and design, and camera interface control design.

PHASE II: Develop a complete focal plane array with high frame rate readout. The capability of this camera to collect high frame rate tracking data or wavefront data will be demonstrated at either the Airborne Laser Advanced Concepts Testbed at White Sands Missile Range or the Advanced Tracking Lab at Kirtland AFB.

PHASE III DUAL USE APPLICATIONS: A successful Phase II completion would lead to integration of the camera into experimental USAF programs, such as the Airborne Laser Advanced Concepts Testbed, that could be used to demonstrate and transition the technology to the Airborne Laser, the Space-Based Laser, or the Ground- Based Laser Technology Program. On the commercial side, this high frame rate camera would be useful for high-speed photographic applications in the SWIR, including process monitoring, quality control, and automated manufacturing, with potential application in the visible spectrum, especially the high-frame rate readout electronics.

REFERENCES:
1. Paul H. Merritt et al., Active tracking of a ballistic missile in the boost phase, in SPIE Proceedings Vol. 2739, Acquisition, Tracking, and Pointing, pp.19-29 (1996).
2. Marcus Schulthess and Steven Baugh, Attitude control a trajectory estimation for the high altitude balloon experiment, in SPIE Proceedings Vol. 2221, Acquisition, Tracking, and Pointing, pp.590-609 (1994).

KEYWORDS: camera, tracking, infrared, wavefront sensor, optical turbulence, quantum efficiency

AF99-012 TITLE: Advanced High Power/High-Energy Laser Technology Emphasizing Light-Weight, Small Volume, High Efficiency

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Develop advanced high power/energy laser technology using electrical discharges (and hybrid electro-chemical approaches) with particular emphasis on small weights and volumes.

DESCRIPTION: With the advent of the More Electric Aircraft (MEA), significant electrical power exists on the F-16 for potential use as directed energy weapons like lasers. Since the 1970's, the consensus has been that chemical lasers were the only practical method to acquire high powers at reasonable weights and volumes. On the other hand, electric lasers required large APU's (Auxiliary Power Units) powered by chemicals stored on the aircraft. This requirement produced larger weights for the laser systems, with the APU sometimes making up to 40% of the total weight of the high power laser system. Consequently, until this time, most of the emphasis for high power lasers suitable for military aircraft has been on chemical lasers. With the demonstration of the MEA, this weight issue for electrical lasers is greatly reduced. Concepts using plasmas to sustain lasing may now become much more practical for their use as high power lasers on fighter aircraft. In addition, the use of such plasmas to promote chemical reactions is also important. Previous electrical discharge techniques employing high energy electron beams are not suitable due to the large weights. Possible use of aircraft jet engines to provide the flowing active gaseous laser mediums should be given special attention in order to minimize weights and volumes. Besides gas phase electric lasers, intermediate and lower power approaches involving solid state lasers, fibers, and semiconductors (PILOT) are also important. High peak powers with variable pulsewidths and PRF are attractive for these lower power systems. Efficiency is most important and integration / compatibility with the aircraft is critical. Laser system

approaches accounting for possible high g-forces (maybe up to 9) should be followed. Although high powers normally involving gaseous mediums are desired, intermediate levels using solid state lasers, fibers, and semiconductors are also important.

PHASE I:Demonstrate, by analysis and possibly through supporting test data, approaches to produce high, intermediate, and low power electrical lasers (and hybrid electro-chemical) having small volumes/weights compatible with F-16 aircraft and other air platforms. Identify critical high-payoff aspects of the laser subsystem technology for further development.

PHASE II:Fabricate and test new approaches to high, intermediate, and low power laser technology demonstrating small volumes and achievable light weights. Integration of the entire laser system into small volumes compatible with the aircraft is critical. Design concepts accounting for the vibrations and acoustics of the aircraft should also be followed in order to assure good laser beam quality occurs with negligible pointing jitter.

PHASE III DUAL USE APPLICATIONS: Potential commercial applications include commercial aircraft and other vehicles, like ground-based vehicles such as robots for illumination/burning/damaging of hazardous waste (chemicals or radioactive contamination). Potential military applications include the HEL laser systems on fighter aircraft for various applications.

REFERENCES:

1. E. F. Yelden, H. J. J. Seguin, C. E. Capjack, and S. K. Nikumb, "Multichannel Slab Discharge for CO2 Laser Excitation", Appl. Phys. Lett., 58, 693 (1991).
2. J. A. Glaze, J. Finzi, W. F. Krupke, "A Transverse Flow cw HCl Laser", 18, 173 (1971).
3. K. R. Newton and R. B. Bernstein, "Cryosorption-Pumped cw Chemical Laser", Appl. Phys. Lett., 33, 47 (1978).
4. L. J. Mawst, A. Bhattacharya, M. Nesnidal, J. Lopez, D. Botez, J. A. Morris, and P. Zory, "High cw Output Power and Wallplug Efficiency Al-free InGaAs/InGaAsP/InGaP Double Quantum Well Diode Lasers", Electronics Letters, 31, 1153 (1995).
5. C. Kennedy, High Power Diode Pumped Laser Pulse Amplifiers", Lasers and Optronics, pp. 13-15, October 1997.

KEYWORDS: fiber lasers, solid state lasers, semiconductor lasers, laser thermal management, diode pumped solid state lasers, high efficiency electric lasers, electric discharge lasers (EDL's), aircraft based electrical storage, hybrid electro-chemical and chemical lasers

AF99-013 TITLE: Portable UHF or VHF Radar for Measuring Wind and the Refractive Index Structure

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop a portable UHF or VHF radar for measuring wind and the refractive index structure parameter.

DESCRIPTION: There is a requirement for a portable UHF or VHF radar that senses wind and the refractive index structure parameter from the lower troposphere to an altitude of 20 km. A range resolution of 150 m is required and the one-way beam width must not exceed 3 degrees. A profile of wind must be sensed at no longer than at three-minute intervals. The power aperture product must be a minimum of 1x100 million Watts per square meter. These radar characteristics are state of the art for permanent installations (see for example Nastrom and Eaton, 1995). Only one VHF radar, a SOUSY radar developed at the Max Planck Institute, was designed with considerations of possibly moving the system, but this has been accomplished only a few times and requires considerable time and manpower (the system is described by Czechowsky et al., 1984). Profilers designed to measure the boundary layer and lower troposphere, typically at 915 MHz, have been successfully engineered for portability. The new UHF or VHF system should be capable of being disassembled within a week, moved to a new site, and reassembled within a week (provided the site has been prepared).

PHASE I: Produce a conceptual design for the portable UHF and VHF radar system. Also, develop a detailed analysis of the predicted performance of each component of the system. Address all electronics, mechanical, and software issues.

PHASE II:Develop and field test a breadboard portable UHF or VHF radar. The performance of this system will be evaluated by comparison with measurements with a TBD system selected by the U.S. Air Force Research Laboratory. Ease of set-up and tear-down of the portable system will be monitored.

PHASE III DUAL USE APPLICATIONS: UHF or VHF radar systems are generally installed once or are moved to a new program with great difficulty and expense. Usually some parts of the system must be replaced since they were permanently installed. Besides the Airborne Laser and ground-based laser programs, other research programs in DoD would benefit with a portable radar system of this type. Several other government agencies would use such a system on research programs and could increase productivity and scope of several studies. On the commercial side, a radar of this type would be useful for air pollution evaluations over moderate times for site characterization studies. It also would be useful to assess wind shear and weather at small airports to determine if a large radar permanent installation is justified as part of a general weather monitoring station due to unique local effects.

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1. Czechowsky, P., G. Schmidt, R. Ruster, 1984: The Mobile SOUSY Doppler Radar: Technical Design and First Results, Radio Science, 19, 441-450.
2. Nastrom, G. D., and F. D. Eaton, 1995: Variations of Winds and Turbulence as Seen by the 50-MHz Radar at White Sands Missile Range, New Mexico, J. Appl. Meteorol., Vol. 34, No. 10, pp2135-2148.
KEYWORDS: radar, troposphere, stratosphere, wind measurements, site characterization, refractive index structure parameter

AF99-015 TITLE: Portable Differential Image Motion Monitor (DIMM) for Measuring Optical Turbulence

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop a Portable DIMM for measuring various optical turbulence parameters.

DESCRIPTION: There is a need for a portable Differential Image Motion Monitor (DIMM) for measuring the transverse coherence length, the isoplanatic angle, and the phase structure function on many research programs, as well as operationally such as at astronomical observatories for turbulent characterization during measurement campaigns. The system should be capable of sensing both stellar sources and of operating over horizontal paths (using laser sources) with up to four pairs of subaperatures with different separation distances. The Atmospheric Turbulence Measurement and Observation System (ATMOS), a system for measuring atmospheric turbulence (Eaton et al., 1988), was developed in the 1980's using custom-designed electronics because nothing was available commercially at that time that would meet the requirements. State-of-the-art sensors and electronics (COTS, when available) must be incorporated into the new system with a wide range of sampling capability (exposure times, frame rates, gains, etc.). Displays and software must be "user friendly" and be easily maintained. A calibration method for the system is required. The telescope used should be of moderate size (14 to 20 inches in diameter) and the tracking should be capable of operating unattended for several hours.

PHASE I: Produce a conceptual design and prototype for the DIMM. Also, produce and demonstrate a detailed analysis of the predicted performance (range of parameters sensed, accuracies, electronics and camera specifications, etc.). Perform preliminary field tests.

PHASE II:Finalize the design and fabricate a DIMM using that design. Produce complete documentation. Extensively field test and evaluate the system under various conditions.

PHASE III DUAL USE APPLICATIONS: Although several DoD programs such as the ABL and ground-based laser programs would greatly benefit with a DIMM using state-of-the-art electronics and sensors, the astronomical community has also shown great interest in such a system. Several measurement campaigns have been conducted at various astronomical sites using unique DoD equipment (Eaton, et al., 1996), and inquiries as to availability, possible costs, etc. of such a system often arise. The ATMOS has been operated at several facilities including Kitt Peak National Observatory, Fred Whipple Observatory, and Apache Point Observatory. A commercially available system would be beneficial, particularly since many major astronomical observatories are now initiating adaptive optics programs.

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KEYWORDS: isoplanatic angle, optical turbulence, site characterization, phase structure function, differential image motion, transverse coherence length

AF99-016 TITLE: Small Inertial Attitude Reference System for Small High-Performance Aircraft Applications

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Develop a small inertial attitude reference system that will contain a stable mirror to reference optical systems.

DESCRIPTION: This project will design and produce a small and inexpensive inertial attitude system that can be used in an F-16 fighter aircraft as a two-axis optical inertial reference. This type of an instrument may be very useful to a program such as the MEA F-16 aircraft that requires an inertial reference for optical pointing. The system is desired to be small enough that it could be mounted

on the secondary mirror of a beam expanding telescope; the goal is to keep the instrument package within a cube 3 inches on a side. The intent of this effort is to conceptualize, design, and produce a prototype unit that is an inexpensive and small inertial attitude reference. An optical surface, such as a small mirror, will be included in the system to provide an inertially stable optical reference. It would be possible to add accelerometers to this unit and obtain a navigation system. However, only the attitude reference will be designed and built under this contract, navigation software will be added by the contractor as s/he deems necessary. The system will be able to operate and measure angular inputs while the telescope is slewing at 1 rad/sec and 2 rad/sec/sec acceleration. It must be able to survive higher rates and accelerations but may saturate. The angular error in the optical reference of this system shall be less than 3 microradians when subjected to the vibration spectrum of a F-16 at 2000-40,000 ft altitude and 0.2 to 2.0 mach number, and less than 1.5 microradians under quiet laboratory operation. Design reviews will cover the components, the system design, and control design concepts for the entire system.

PHASE I: Design the attitude reference system and demonstrate that such a miniature system is within the state of the art. Establish the feasibility of producing the small package and show how this package can be used with a telescope to significantly improve the pointing accuracy.

PHASE II: Develop and demonstrate the components for the two-axis attitude reference system. The instrument shall be demonstrated as a complete system. It is expected that this phase will demonstrate the system operation and include detailed characterization of the control loop performance. If desired, the Air Force will work with the contractor to obtain use of the inertial test equipment at Holloman AFB.

PHASE III DUAL USE APPLICATIONS: It is expected that an ultra small system as conceptualized here would have several commercial and military customers. The military applications will be on all sorts of pointing telescopes for directed laser energy weapons, imaging, and optical communication systems. The commercial use of the system would include navigation systems for land vehicles and possibly aircraft. If the price can be made low enough for the automobile industry, the product would obviously have a huge market. It is expected that the contractor will design a system with many options during Phase I, so that an as-large-as-possible commercial market will be available.

REFERENCES: H. Wrighley and T. Denhard, Gyroscope Theory, Design, and Instrumentation, (MIT Press, Cambridge, MA), 1969.

KEYWORDS: gyroscopes, reference frames, optical pointing, inertial guidance, high g-factor effects, aircraft guidance system

AF99-017 TITLE: Active Remote Sensing Technologies for Chemical Effluent Detection

TECHNOLOGY AREA: Chemical and Biological Defense

OBJECTIVE: Develop component technologies that facilitate meeting performance requirements for active (laser-based) chemical effluent detection.

DESCRIPTION: The growing reality of the threat of chemical attack in both military and civil environments, and the ready availability of chemicals to process deadly toxins and narcotics, indicate a need for suitable chemical detection devices. Remote sensing technologies suitable for counter-drug, counter-terrorism or counter-proliferation applications could provide early warning of a threat in the processing stages of chemicals, or could provide evidence of a suspected release. Chemical effluents may include fuel emissions, industrial by-products of chemical or biological production, as well as toxic chemical agents. Technologies that facilitate longer range detection and quantification of chemical species using active remote sensing devices will be considered for development. Of particular interest are components or systems that improve detection and identification performance of an unknown chemical target, or that improve the operational effectiveness of devices, including compactness, ruggedization and reduced power requirements.

Chemical spectral signatures extend across the entire infrared spectrum, but for detection purposes, the atmospheric transmission windows between 3-5 microns and 8-12 microns provide the greatest potential for detection. Required technologies include:

1. Receivers in this region are susceptible to significant detector noise, and enhancements to receiver detection sensitivity, including noise suppression and signal enhancement, are desirable.

2. Of interest is pulsed laser source technology that shows promise of reaching average powers on the order of >10W in MWIR and 100W in LWIR over all lines in a 1 to 2 micron band, with relatively narrow line width (<0.5 cm-1) and high pulse repetition frequencies (100Hz-10kHz). Also of interest are tuning mechanisms that facilitate tuning over a sequence of >20 lines across the operating band.

3. Automated control of 12 bit, streaming data acquisition at up to GHz bandwidths, real-time signal processing and chemometric analysis algorithms, automated pattern recognition and user-friendly, portable workstations.

PHASE I: Define the system concept and demonstrate key component technological milestones and preliminary design

of system or component deliverable. The system approach is meant to ensure that the components developed have utility in meeting the requirements defined above, and can be suitably field tested with existing GFE hardware if necessary.

PHASE II:Complete component design, fabrication and laboratory tests. Define field test objectives and recommended test plan, including required GFE.

PHASE III DUAL USE APPLICATIONS: These lidar systems could be used in both the military and private sectors for counter-drug, counter-terrorism purposes with little or no modification.

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KEYWORDS: lidar, gas lasers, chemical sensing, solid state lasers, infrared detection, stand-off detection, chemometric analysis, chemical cloud detection, differential absorption lidar (DIAL)

AF99-018 TITLE: High Efficiency Electric Laser

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Develop Highly Efficient, Compact, Light Weight, Electrically Driven Lasers for Adjunct Spaced Based Laser (SBL) missions.

DESCRIPTION: The Air Force is currently developing chemical laser systems for use in space. With their energy stored chemically, they are well suited to long-run-time high power applications. The Air Force SBL program has a requirement for lower power lasers that are electrically driven and can be used periodically over an extended time frame. The lasers must be highly efficient at the conversion of electrical power into a diffraction-limited laser beam. These lasers must be compact and light weight. This solicitation is for the development of lasers, laser subsystems, or enabling technologies that improve space based electric lasers. Such technologies include: high-efficiency semiconductor lasers; diode pumped solid state lasers; diode pumped fiber lasers; efficient optical system for coupling semiconductor laser emission into fibers and gain media; novel electrical storage; and innovative thermal management.

PHASE I: Design and model the laser, laser system, or enabling technology, and perform adequate proof-of-principle demonstrations to give confidence for the success of a Phase II program.

PHASE II:Based on initial designs developed in Phase I, develop or fabricate demonstration hardware, conduct in-depth testing, and refine prototype hardware or design.

PHASE III DUAL USE APPLICATIONS: Air Force applications for this technology may have important commercial parallels, such as communications, medical, and materials processing lasers. Military applications include space-based optical information exchange, designation, and illumination. The objective of Phase III is to make the technology developed in the first two phases commercially available for both private-sector and military applications.

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1. "35-Watt CW Single mode Ytterbium Fiber Laser at 1.1 microns", Muendel M., Engstrom B., Kea D., et. al., Conference on Lasers and Electo-Optics, CPD-28, May 1997.
2. "High-performance Al-free active-region diode lasers", Mawst L.J., Conference on Lasers and Electo-Optics, CMA3, May 1997.

KEYWORDS: fiber lasers, electric lasers, space-based lasers, semiconductor lasers, laser thermal management, space-based electrical storage, diode-pumped solid-state lasers, high efficiency electric lasers

AF99-019 TITLE: Lightweight Ultra-Wideband Antennas

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Develop new concepts and enhanced capabilities in lightweight wideband microwave antennas for transmitting and receiving.

DESCRIPTION: Lightweight wideband antennas are of interest for a variety of potential applications that range from radar systems on lightweight aircraft, to countermine and unexploded ordnance location, to communications. This technology is of current interest to the Air Force Research Laboratory, Directed Energy Directorate at Kirtland AFB, NM, where research efforts have been underway for a number of years. Wide bandwidth, which can handle a large number of frequencies in the range from 30 MHz to 10 GHz, is of interest for both continuous wave and transient signal transmission. Transient parameters of interest include risetimes in the range of 10-300 pS and pulse widths from a few hundred picoseconds to 5 nS.

PHASE I: Develop and demonstrate innovative applications utilizing ultrawideband microwave technology. Investigate basic feasibility of the proposed applications to determine the specific approaches, identify critical development requirements and potential risks, and provide a basis for determining the potential success of a Phase II effort.

PHASE II:Develop and fabricate a prototype system, conduct laboratory and other tests which will demonstrate a capability with clear commercial potential. Develop commercial partnership interests for a Phase III production and marketing program.

PHASE III DUAL USE APPLICATIONS: The civilian sector has similar requirements for locating buried objects such as pipes or underground cables, and for performing inspections on concrete structures such as bridges or building foundations. Potential uses also include wideband or transient radar on aircraft, and wideband, multi-channel communications for ships, aircraft, and satellites.

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1. C.E. Baum, L. Carin, and A.P. Stone, eds., "Ultra-Wideband, Short-Pulse Electromagnetics 3, Plenum Press, New York, 1997.
2. E.G. Farr, G.D. Sower, and L.M. Atchley, "Design Considerations for a Half Impulse Radiating Antenna," PL-TR-97-1058, Phillips Laboratory (now Air Force Research Laboratory), Kirtland AFB NM, January 1996.
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KEYWORDS: antennas, ultra-wideband, transient radar, high power microwave, electronic fields and waves, multi-channel communications

AF99-020 TITLE: Modulated Corner Cube Concept for Laser Communications

TECHNOLOGY AREA: Sensors

OBJECTIVE: Demonstrate a minimum-impact concept for modulation of the light reflected by a corner cube, achieving a modulation rate in excess of 1 Mhz.

DESCRIPTION: Laser communication approaches can meet secure, high-bandwidth communications requirements, but standard laser communication concepts--in which each end of the communications link has a laser source, optical telescope, and acquisition, pointing, and tracking system--are not always appropriate for every potential application. This is particularly true if one end of the communications link is significantly constrained in weight, power consumption, reliability, or cost. However, if an application with these constraints also has low to moderate modulation requirements, an alternate laser communications concept becomes attractive. One example, cited in the following description, is laser communications to and from a very small satellite and the ground; other applications can also be envisioned.

The alternate concept for the small satellite laser communications application is as follows: First, a laser site on the ground illuminates the satellite with a laser having a CW beam. Onboard the satellite is a corner cube, which reflects the incident laser light back to the transmitter on the ground. Associated with the corner cube is a modulation mechanism that reacts rapidly to change the intensity or the polarization of the reflected light (for example, this might be liquid crystal light modulator). By appropriately controlling the modulator, the laser light reflected back to the ground station from the corner cube is modulated with the comm. signal. This approach offers the potential advantage of significantly reducing the size and complexity of hardware required onboard the satellite for laser communications while maintaining the secure communications advantages of laser communications in general.

The feasibility of the modulated corner cube concept for laser communications has been investigated theoretically, and ground- and balloon-based field experiments have been conducted. Ground field experiments were conducted in December 1994, and a high-altitude balloon experiment was conducted in September 1996, using off-the-shelf hardware for a proof-of-principle demonstration. The experiments used 1" corner cubes coupled with a liquid-crystal screen as the modulating element. The tests were

100% successful, with the received signal strength exceeding that predicted before the tests. However, because of the limitations of the liquid crystal screen, the modulation rate was limited to 50 kbps.

The major technology issue in establishing the modulated corner cube concept for many military laser communication applications is the development of the modulation approach to meet the operational requirements for higher modulation rates. To substantially increase the modulation rate beyond that possible with off-the-shelf liquid crystal screens, alternate means of modulation must be investigated and developed.

PHASE I: Conceive and evaluate a range of alternate concepts based on the potential ability to meet operational modulation requirements, technical feasibility, and expected impact on the platform in an operational implementation.

PHASE II: After the Phase I concept evaluation, further develop the most promising concepts (one or two), with the goal of producing proof-of-principle hardware for experimental evaluation and demonstration of performance in the laboratory.

PHASE III DUAL USE APPLICATIONS: The modulated corner cube concept for laser communications is particularly attractive in applications where one end of the communications link is significantly constrained in weight, power consumption, reliability, or cost. By using this concept, low-impact, secure communications links could be established between: 1) ground and very small satellites, 2) manned aircraft and UAVs, 3) satellites and UAVs, 4) satellites or aircraft and unattended ground sensors, and 5) aircraft and ground personnel (special ops, search and rescue operations).
Commercial analogs of these military missions can also be considered. For example, several commercial communication satellite constellations are being launched or are planned for future launches (Iridium, Teledesic, Celestri, etc.). Satellite-to-satellite communication links for these constellations typically use laser communications, but the satellite-to-ground links are always based on RF communication. If high modulation rates can be demonstrated with the modulated corner cube concept, then the larger RF communications package on the satellite could be replaced with a modulated corner cube system, with substantially less impact on the satellite platform

REFERENCES: C. M. Swenson, C. A. Steed, I. A. De La Rue, and R. Q. Fugate, "Low Power, FLC- Based Retromodulator Communications System," Proceedings SPIE Vol 2990, 1997, pp 296-310.

KEYWORDS: corner cube, optical modulation, laser communications, secure communications, liquid crystal screen, high bandwidth communications

AF99-021 TITLE: Space Capable, Optically Transparent Thin Films

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop a space capable thin film with properties that minimize the induction of optical aberrations upon transmission through the film.

DESCRIPTION: AFRL has demonstrated that thin film polymeric membranes are potentially a valid technology for a large concave mirror when used with a real time holographic correction scheme. Pressure is used to create the doubly curved mirror. The membranes on these large apertures will range in thickness from 10 micrometers to 150 micrometers. This technology is very well suited for deploying an optical system to space, since the membranes can be packaged on the ground and erected after deployment. An optically transparent canopy matched with a reflective film will comprise the pressure vessel. This SBIR is focused on the development of an optically transparent canopy. The science and engineering community has done a lot of quality work in the development of optically transparent thin films. The optical performance of these films was primarily judged on its transmissive power characteristics. Since this canopy will be used in an imaging system, both amplitude and phase of the incoming light must be considered in the design space with phase maintenance being clearly the most important aspect. This typically implies that the thickness and the homogeneity of the membrane be held to a very tight tolerance. Specifically, the transmission losses during a single pass should be limited to 5% of the total input power; this total includes both Fresnel losses and absorption. Maximum absorption should be limited to 2% of the total input power. In addition, the wavefront phase error introduced over an aperture of 30 cm during a single pass should be limited to less than 25 nanometers rms. Optical phase testing of these membranes will be completed at the Phillips Site as long as the sample sheets are at least 1 meter in diameter with the area under test being the central 30 centimeters. Phillips will mount the film in a proven test fixture. Test data in the form of interference fringe patterns will be returned to the contractor for evaluation. Two double pass tests will be performed: One will be taken when th thin film is mounted flat, and the other will be pressurized to a curvature with a central deflection to diameter aspect ration of 1:50. Optical losses due to transmission effects shall be accomplished by the contractor. Note that the thickness of the membrane intentionally is not specified and is not considered a crucial design point. This canopy must maintain its optical properties for five years when placed in an environment similar to a geosynchronous orbit around the earth. After five years, transmission losses should still be less than 10% of total input power, and phase error as described above should be maintained below 100 nanometers rms.

PHASE I: Fabricate an optical quality thin film with the goal of achieving the requirements described above. Phase testing

will be accomplished by Phillips Site, and transmission characterization shall be completed by the contractor. Complete characterization of the material's mechanical, space survivability and optical properties is required.

PHASE II:Identify the process necessary to scale this thin film to sizes larger than 8 meters in diameter and demonstrate the feasibility of this process by producing, testing and characterizing a smaller film. The techniques used to produce the film should be scaleable to the production of larger films.

PHASE III DUAL USE APPLICATIONS: An optically transparent thin film that preserves both phase and amplitude has many general uses, including: inexpensive optical windows for terrestrial telescope for both home and commercial use; inexpensive windows used by research, testing and manufacturing companies to move beams from a clean room to another location; durable high quality optical beam splitters; substrates for membrane mirrors with curvature; and light shields in space.

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KEYWORDS: canopy, thin film, inflatable, space capable, large aperture, membrane optics, optically transparent

AF99-022 TITLE: Room-Temperature Engineerable Nonlinear Optical Materials

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Produce engineerable nonlinear material that operates at room temperature and is sufficiently nonlinear to function at continuous-wave power levels.

DESCRIPTION: Periodic poling of ferroelectric nonlinear crystals has revolutionized nonlinear optics. Combining microlithography with ferroelectric domain reversal has led to engineerable nonlinear optical materials. Periodically poled lithium niobate (PPLN) is available in sufficient lengths and has enough nonlinearity to produce a singly resonant, continuous-wave, optical parametric oscillator with a threshold of less than 5Watts. However, lithium niobate is also photorefractive. The optical fields in the material liberate free carriers. These free carriers eventually migrate out of the optical fields. The displaced carriers create static electric fields which, through the electro-optic effect, generate index changes. These index changes lead to scattering, losses, and phase mismatch of the nonlinear optical process. The index changes can be removed by heating the crystal, which redistributes the displaced carriers and eliminates the static electric fields. Investigators have found the index variations can be reduced significantly by operating the devices at elevated temperatures. Typical operating temperatures for ~10 Watts of infrared pump power are about 180 degrees C. Such elevated temperatures are inconsistent with many AF application requirements.

PHASE I: Demonstrate an engineerable nonlinear optical material that can operate at room temperature. The material will have sufficient nonlinearity for operating singly resonant, continuous-wave, optical parametric oscillators with threshold pump powers in the infrared of less than 5 Watts. The material should have transmission characteristics comparable to or exceeding that of lithium niobate.

PHASE II:Develop manufacturing techniques and technologies to produce this engineerable material for integration into devices.

PHASE III DUAL USE APPLICATIONS: Applications are numerous. Frequency-agile sources could be used in remote sensing and chemical detection, as well as numerous medical applications. AF applications include calibration and bore sighting of infrared systems.

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KEYWORDS: quasi-phase matching, nonlinear optical materials, optical parametric oscillation, ferroelectric domain inversion, periodically poled lithium niobate, nonlinear optical frequency conversion

AF99-023 TITLE: High Average Power Modulator for Multi-Gigawatt HPM Sources

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Develop a prototype modulator capable of driving a vacuum electron beam diode for a repetitively pulsed, multi-gigawatt high power microwave source.

DESCRIPTION: During the last couple of years, the Air Force Research Laboratory and other organizations have been developing High Power Microwave (HPM) sources capable of producing in excess of 1 GW of Rf power, but only on a single-pulse basis. A typical process in the development of a commercial microwave tube by the conventional microwave tube industry is to repetitively pulse the tube, and over several thousand pulses progressively turn up the Rf power and slowly condition the tube. Conventional modulators are incapable of powering any multigigawatt HPM tubes to enable investigating this conditioning process. Hence, an innovative pulsed-power R&D effort is required. The primary emphasis is to use innovative design concepts to minimize the cost and packaging while maintaining the reliability and reproducibility of the output electrical pulse. The electrical considerations must include the ability to apply a maximum 600 kV pulse to a vacuum diode with an arbitrary, but fixed impedance between 10 and 50 Ohms with no more than 5% reflection from the load back to the modulator. The pulse shape must satisfy a 1 microsecond flattop (+/- 5 %) with a 50 nanosecond rise and fall time. Given that this modulator will be used in a repetitive fashion (at up to 100 pulses per second during a 10-second period), cooling issues for the pulse power components and the technique for charging the modulator will be important. Since some experiments using this modulator may not require the full duty cycle, and perhaps only a few pulses, a control system must allow selecting the number of pulses per burst and the pulse repetition rate. The physical size of the modulator should be minimized, and at a maximum should not exceed 25 ft (length) by 10 ft (width) and 10 ft (height), and the weight should be less than 6,000 lbs not counting weight of the insulating medium (such as transformer oil). The interface between the modulator and any HPM tube must be compatible with obtaining a base vacuum of order 2.0E-9 Torr. Given that laboratories exist in various locations (e.g., Albuquerque is at an altitude of 5,300 feet), means that consideration must be given to the possibility that the ambient air pressure is reduced if air insulation of high voltage components is planned. The power supply to energize the modulator is not a deliverable for this project. If transformer oil is chosen as the insulating medium, the oil is not to be delivered with the modulator. The control console for the modulator must be able to be located at least 150 feet from the modulator and provide for interfaces to any high voltage power supply and any laboratory safety interlock systems.

PHASE I: During Phase I of this project the modulator should be designed electrically and mechanically. Consideration will also be given to the source of the prime power, specifically are the power supply requirements consistent with typical laboratory electrical power grids. The mechanical layout must allow for attaching a vacuum system typically used in laboratories for HPM sources, and be consistent with any electrical cross-talk between components and high voltage isolation requirements.

PHASE II:During Phase II a prototype modulator will be built and tested for single shot reproducibility and modest repetitive operation (~ 1 pulse per second for 10 pulses) with tracability to the full burst mode requirement. The main demonstration will be to drive a 10 Ohm, 20 Ohm, and 50 Ohm resistive load and show that the output current pulse tracks the input voltage pulse with minimal inductive loss. The modulator and all documentation will then be delivered to AFRL for installation and final acceptance testing with our HPM sources.

PHASE III DUAL USE APPLICATIONS: Economical, high average power modulators have an amazing potential market for Air Force missions of ACC and AFSOC and civilian markets. Companies and markets already exist for treatment of food and hazardous waste. The major limit for them is the maximum average power available which limits the amount of material that may be processed. Also, there are requirements for economical average power modulators for driving communications systems, modulators for the microwave tubes for the International Linear Collider, Free Electron Laser technology, inter-planetary radio-astronomy, and deep sky radar.

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2. M. Haworth, et al, "Recent Progress in the Hard-Tube MILO experiment", Proc. SPIE, vol. 3158, July 1997

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KEYWORDS: pulse power, high voltage, average power, pulse modulator, high power microwaves, repetitive pulse modulation

AF99-026 TITLE: Ultra-Narrow Linewidth, Tunable Single-Frequency Ytterbium Laser

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop an ultra-narrow linewidth, single-frequency, TEM00, linearly polarized, low-power (few hundred mW) cw laser, based on trivalent Ytterbium (Yb) in a Yttrium-lithium flouride (YLF) host (1018 nm) as well as in a Yttrium-aluminum-garnet (YAG) host (1030 nm).

DESCRIPTION: Diode-pumping of the trivalent Ytterbium ion has received significant interest because of its efficient lasing operation and high-power scalability. Examples employing a YAG host yield 91% quantum efficiency using a 940-nm pump wavelength with a laser wavelength of 1030 nm. Using a uniaxial host crystal of (YLF), 94.3% quantum efficiency results from using a pi-polarized pump wavelength at 960 nm with an s-polarized lasing wavelength at 1018 nm. Though both hosts are ideally suited for scalable high-power operation, the YLF crystal adds the benefit of low-thermal lensing and negligible birefringence when diffraction-limited operation is desired.

There are many applications that require or could benefit from the use of a scaleable, frequency stable, tunable laser source. A few examples include pump sources for single-frequency optical parametric oscillators (OPO), resonant non-linear frequency conversion, spectroscopy, laser clocks, and remote sensing. Unfortunately, commercially available robust, low-power, single-frequency master oscillator lasers do not exist at the Yb laser emission wavelengths. If available, injection-locking techniques or regenerative amplifiers could be used to scale these low-power sources into high-power, single-frequency, cw laser devices thus increasing the number of possible applications. The YLF host laser wavelength is particularly suited to pumping praseodymium ion in fiber amplifiers for 1.3-um communication systems and to pumping an OPO with intracavity sum-frequency generation (SFG) producing a 589 nm laser for use as a sodium beacon guide star in telescope adaptive-optics systems.

A number of approaches have been used to obtain single-frequency operation in diode-pumped lasers including monolithic non-planar ring oscillators (NPRO), birefringent tuning filters, twisted-mode resonators, and microchip laser designs. In particular, the robustness and frequency stability obtained with the NPRO design for Neodymium:YAG lasers sets a user-friendly standard to strive toward. New, diffusion-bonding processes may make monolithic designs utilizing the Yb ion possible. In addition, though broad-frequency tuning may be achievable, emphasis must first be placed on the laser's free-running frequency stability (better than a few tens of kHz/s for both jitter and thermal drift) for ease of injection locking. Because of the number of applications requiring an ultra-narrow linewidth, it is expected that fast frequency tuning (at least several tens of kHz bandwidth) of the laser device be incorporated for locking to external references. Examples of external references might be a high-finesse Fabry-Perot cavity, using the second harmonic tuned to an iodine spectral line, or possibly, if a wide-tunability (up to 1064 nm) is achieved tuning to molecular overtone resonance lines in C2HD, C2H2, or CO2.

PHASE I: Resonator design trade-off analyses are to be conducted, including modeling, to determine the best configuration for ultra-narrow linewidth, tunable single-frequency low-power laser oscillators. Designs should emphasize free-running frequency stability and reliability. The preliminary designs should include both YAG and YLF hosts to determine if similar technology could be used for separate laser systems. Experimental investigations should be conducted to demonstrate the feasibility of the resonator designs at the lasing wavelengths of 1030 nm and 1018 nm.

PHASE II:The proven resonator designs for both YAG and YLF hosts are to progress into more compact, robust packages thus demonstrating their commercial feasibility. This stage will demonstrate the range of the devices' wavelength tunability and their free-running frequency stability. Demonstrate fast frequency tuning and all other aspects of the laser devices. Any other aspect related to the progression to a commercialization phase will be considered at this point in the program.

PHASE III DUAL USE APPLICATIONS: Commercial applications include laser clocks, spectroscopy, creating a sodium beacon guide star for telescope adaptive-optics systems, and a pump source for praseodymium ion in fiber amplifiers for 1.3-um, fiber-laser communication systems. Military applications include illuminators, remote-sensing systems, long-coherence-length lasers, laser clocks, satellite cross-link communications, and creating a sodium beacon guide star for telescope adaptive-optics satellite-tracking systems.

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KEYWORDS: MISER, chip laser, ring resonator, ring chip laser, microchip laser, single-frequency, Ytterbium:YAG (Yb:YAG), Ytterbium:YLF (Yb:YLF), traveling-wave resonator, monolithic ring resonator, non-planar ring oscillator (NPRO)

AF99-029 TITLE: Optical Interconnects for Satellite Applications

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop improved components, technologies, or systems for high-speed optical interconnects for space.

DESCRIPTION: Optical interconnects can relieve data bottlenecks that occur between chips, boards, or modules. They have the potential for reducing the latency, excessive weight, and EMI interference found in hardwire systems and increasing computing speed. Due to limitations on capabilities for downlink data rates from satellites, on-board processing is necessary for applications involving large amounts of data, such as imaging and surveillance. On-board computer power is also needed for switching and routing information in communications satellites. This drives the need for high-speed optical interconnects. Microelectromechanical machines (MEMs) or microoptoelectromechanical machines (MOEMs) may be useful as low power switches. The thrust of this topic is to make optical interconnects more readily applicable in space or to improve the performance of interconnects that are already applicable. Improvements might include: decreased power consumption, increased data rates, lower susceptibility to upset due to space radiation, lower weight, and applicability in new systems. Replacement latching and buffering microelectronics which decrease system weight and increase bandwidth performance to a level greater than 100 MB/s, are needed.

PHASE I: Review the existing technology to determine a baseline for the performance of current interconnects. Show that the new concept will increase the performance of potential satellite systems. Identify areas of risk in the interconnect concept and perform theoretical analysis, simulation, and laboratory demonstrations that show that the interconnect can be fabricated and assembled.

PHASE II:Fabricate the interconnect and demonstrate that it increases the capability of a processor or computer that is appropriate for application in satellites.

PHASE III DUAL USE APPLICATIONS: Enhanced processing capability will be useful for controlling switching circuits and for signal processing in military as well as commercial communications satellites. Therefore, the commercialization potential should be high.

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KEYWORDS: MEMs, MOEMs, optics, interconnect, space applications, radiation tolerant, optical interconnect, optical communications

AF99-030 TITLE: Micro-Latchup Characterization

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop circuit to protect microcircuit from improper operation or burn-up when it enters the state of micro-latchup.

DESCRIPTION: Many commercially available advanced technology CMOS (complimentary metal-oxide semiconductor) and bipolar integrated circuits are latchup susceptible to single event effects caused by heavy ions or protons from cosmic rays or solar flares. This characteristic makes them unsuitable for satellite applications. While the subject of latchup protection has been the object of some previous/current investigations, the subject of micro-latchup has not been addressed. Micro-latchup is a low-level latchup condition that occurs in some types of commercial microcircuits (like microprocessors, digital signal processors and application specific integrated circuit [ASIC] chips). In the micro-latchup case, some small area of the chip enters latchup, which is a condition

that prevents its proper operation and can also damage the device. A symptom of this condition is a very slight increase of the supply current into the IC (integrated circuit) device. Putting the device in the standby mode makes this condition more readily detectable. If commercially available IC's are to become space qualified, a low cost, effective process/mechanism must be developed for identifying/rectifying IC's in micro-latchup. The successful remedial circuit must ultimately become an integral part of the IC.

PHASE I: 1) Establish procedure for the detection of very small over currents/micro-latchup conditions, 2) design/fabricate prototype anti micro-latchup circuit, and 3) demonstrate sensitivity, stability and accuracy of the prototype circuit.

PHASE II: 1) Integrate the anti micro-latchup circuit into representative ASIC circuits (to prevent or safely recuperate from micro-latchup), and 2) demonstrate sensitivity, stability and accuracy of the integrated device.

PHASE III DUAL USE APPLICATIONS: Micro-latchup is basically a phenomenon caused by radiation. Commercial applications of the anti micro-latchup circuit lie in IC's used in military/commercial satellites. Commercially available micro-latchup immune IC's would result in significant cost reduction in all space vehicles.

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KEYWORDS: CMOS, latchup, protons, ASIC chips, bipolar IC, heavy ions, stand-by-mode

AF99-031 TITLE: Thin Film Photovoltaic Blanket for Auxilliary Spacecraft Power

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Develop space-qualified, large area, thin-film amorphous or polycrystalline semiconductor solar photovoltaic cells integrated on a flexible lightweight polymer substrate.

DESCRIPTION: Thin-film amorphous and polycrystalline semiconductors have been in development for the terrestrial photovoltaic market for over 20 years. Power generation efficiencies of 6-10% are achievable in large area product for ground applications. Only within the last five years has interest grown to apply this technology to the space market. Even though end item efficiencies are lower than conventional single crystal solar cell photovoltaics for space, the primary advantages of thin-film amorphous and polycrystalline photovoltaics are: 1) minimal degradation due to space charge particle radiation environment, 2) potential low fabrication and manufacturing costs, 3) inherent light weight technology, 4) variable circuit design based on thin film fabrication methodology, and 4) flexible substrates can provide light weight structural support. Based on these potential advantages, the object of this project is development of a space qualified thin-film amorphous silicon or polycrystalline semiconductor photovoltaic cell on a light-weight flexible substrate, integrated with a spacecraft thermal blanket. Since a thermal blanket is used to reflect visible and infrared wavelengths, a top layer of a thin-film and flexible photovoltaic on a KAPTON substrate could be implemented to absorb and convert a portion of the visible and infrared energy to power. The purpose of the resulting device is power enhancement, not replacement of the primary power source, to aid in peak power generation for the spacecraft and additional battery charging capability during times of extended payload operations.

PHASE I: 1) Develop a suitable thin-film photovoltaic deposition technique, 2) fabricate a prototype 0.5 ft x 0.5 ft thin-film photovoltaic on a flexible substrate, including applicable circuitry, and 3) demonstrate that the prototype photovoltaic operates at greater than 8% power generation efficiency.

PHASE II:1) Improve cost effective producibility of Phase I prototype photovoltaic and increase power generation efficiency to > 10%, 2) integrate thin-film photovoltaic with flexible thermal blanket, and 3) fabricate (mutually agreed-upon) large area product and demonstrate power efficiency, flexibility, and other attributes of pre-production prototype photovoltaic.

PHASE III DUAL USE APPLICATIONS: A successful, low cost, large area, thin film amorphous or polycrystalline semiconductor photovoltaic cell, mounted on a light weight flexible substrate, displaying at least 10% power generation capability, will have a multitude of terrestrial (swimming pool heaters, domestic hot water heaters, etc.) and space-based (battery charging) auxiliary power applications.

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2. K. Tabuchi, et al.," Improvement of Large-Area SCAF Structure a-Si Solar Cells with Plastic Film Substrate," 26th IEEE Photovoltaic Specialists Conference (1997).
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KEYWORDS: solar cells, solar array, auxiliary power, thermal blanket, amorphous silicon, thin-film photovoltaic, polycrystalline semiconductor

AF99-032 TITLE: Satellite Vehicle Tracking via Optical Phase Conjugation

TECHNOLOGY AREA: Sensors

OBJECTIVE: Apply optical phase conjugation principles to satellite vehicle tracking.

DESCRIPTION: Optical Phase Conjugation (OPC) is an optical process whereby wavefronts of light are reversed in phase and direction. One result of OPC is a Phase Conjugate Mirror (PCM) which reflects diverging light so that it converges back to its source point. The PCM is a 3-D mirror which can be created from a solid, liquid, or gas by applying the process of "4 Wave Mixing" to the substance. A satellite vehicle equipped with a PCM could be illuminated by a laser and reflect the laser back with very little amplitude or phase degradation, because the OPC process reverses the effect of atmospheric turbulence. Another OPC-derived capability is an "induced laser," in which a PCM acts as a lasing medium in conjunction with a reflective surface. When the PCM starts lasing, some scattered light reflects off of the reflective surface, creating a self-sustaining laser beam between the PCM and the reflective surface. When the reflective surface is moved, the laser beam moves with the reflector because the beam is optically locked with the reflector. The advantage of a self-locking laser beam to the problem of satellite vehicle tracking is clear--the accuracy and simplicity of satellite vehicle tracking could be enhanced greatly. Since the "induced laser" effect uses an reflective surface, the range of the self-locking effect may be limited due to atmospheric turbulence as well as beam divergence from the reflective surface, and therefore may be suitable only for space-based tracking.

PHASE I: Phase I includes the setup and testing of "4 Wave Mixing" phase conjugate mirrors in the laboratory, with the objective of finding space-qualified mirror material. Continued testing of the phase conjugate mirrors is necessary, with regards to specific constraints (simulated atmospheric turbulence, total mirror reflectivity, reflectivity vs. frequency), in order to develop a database of experimental results. Phase I also includes testing an "induced laser," with the objective of finding the maximum separation distance between the PCM laser and the reflective surface that supports the self-locking laser effect, in order to determine whether an "induced laser" could be used to track satellite vehicles from a ground station.

PHASE II: Phase II includes creating a proof-of-concept demonstration of the "4 Wave Mixing" phase conjugate mirror by installing one on an aircraft and illuminating the aircraft with a low power laser to determine the efficiency of reflection of the mirror in non-laboratory conditions. As part of the same experiment, an "induced laser" reflector would be installed on the aircraft, and a lasing phase conjugate mirror on the ground would attempt to "track" the aircraft at various altitudes and angles.

PHASE III DUAL USE APPLICATIONS: As satellite vehicle density increases, the need for tighter satellite vehicle tracking accuracy is evident. Commercial and military satellite vehicle tracking systems that need to be migrated onto satellite vehicle platforms would benefit from the potentially small size and high accuracy of optical phase conjugate laser tracking. The "induced laser" concept could be applied in the aviation industry as a short range automated landing beacon designed to passively track and guide aircraft down to safe landings.

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KEYWORDS: wave mixing, "induced laser", adaptive optics, phase conjugate mirror, satellite vehicle tracking, optical phase conjugation (OPC)

AF99-033 TITLE: Developing a Global Ionospheric Assimilation Model

TECHNOLOGY AREA: Battlespace Environments

OBJECTIVE: Develop a global ionospheric assimilation model that correctly incorporates both ground-based and satellite observations from a wide variety of sensors.

DESCRIPTION: This effort seeks to address the specific problem of how to synthesize and incorporate--into currently available, theoretically-based models--the large amounts of ionospheric data that are available from a variety of sensors. This is an attempt to develop a global, assimilative ionospheric model which currently does not exist. If successful, such a model would significantly broaden the applicability and usefulness of ionospheric observations, in general, and would improve the ability to specify and forecast ionospheric parameters globally. The maturity of the global, physically-based, theoretical models to realistically reproduce, in a climotological sense, large-scale ionospheric plasma distributions and features has been well-established by a number of scientists (Preble et al., 1994; Schunk, 1996; Anderson et al., 1997). While the validation and verification of these models has historically been carried out using a limited set of observations over limited geographical regions (low, mid or high latitudes), to date there has been no concerted effort to develop a global, assimilative ionospheric model. The proposed model should incorporate a wide variety of ionospheric observations, meld these appropriately into the model, and produce global distributions of ion and electron density profiles.

There is an ever-growing database of ionospheric observations being obtained from both ground-based and satellite sensors. These sensors include 1) ground-based digital HF ionospheric sounders measuring bottomside electron density profiles, 2) ground-based dual frequency GPS receivers obtaining slant TEC values, 3) ground-based HF radars such as the SuperDarn network in the northern and southern hemispheres measuring ionospheric ExB horizontal drift velocities, 4) two DMSP satellites obtaining in situ electron and ion densities and temperatures at 840 km as well as energetic particle precipitation fluxes and high latitude ExB drift velocities, 5) a GPS/MET low earth orbit (LEO) satellite measuring TEC profiles up to 740 km, 6) a TOPEX dual frequency altimeter on the Poseidon satellite measuring vertical TEC values over the ocean areas, and 7) several EUV satellite sensors (Polar Bear, POLAR, ARGOS) measuring UV radiances from the daytime, nighttime and auroral regions. This work will lay the foundation of how to incorporate the SSUSI and SSULI UV sensor data into ionospheric models.

The availability of this model would immediately serve numerous customers by providing the best ionosphere as a basis to generate tailored products that mitigate impacts on both DoD and civilian operational systems. This is exactly the type of model which is required to move from global ionospheric climotology to global ionospheric "weather". It is appropriate, now, to generate an ionospheric assimilation model because there is an ever-growing database of ionospheric observations from both ground-based and satellite-borne sensors. Additionally, there exists the potential for even greater data sources from the proposed suite of GPS/MET-like satellite sensors, an expanded network of ground-based dual frequency GPS receivers in the International GPS Service for Geodynamics (IGS) network, and the two UV imagers, SSUSI and SSULI, due to fly on DMSP F16 and above.

PHASE I: Develop the preliminary design and concept which describes 1) how the global ionospheric assimilation model will be constructed and how it incorporates a wide variety of observations, 2) what the observations are and what sensors are required, and 3) how the model will be validated once it has been constructed.

PHASE II:Construct a global ionospheric assimilation model, acquire the datasets that demonstrate the accuracy of the model and then validate this accuracy under all conditions according to the validation scheme developed in Phase I.

PHASE III DUAL USE APPLICATIONS: The ionospheric model developed under this program will be useful for many civilian applications. All civilian users (a million plus) of single frequency GPS receivers require realistic ionospheric corrections to achieve accurate navigation position information. This includes all private and commercial aircraft utilizing the future FAA Wide Area Augmentation System (WAAS). The outputs of the assimilation model would provide these corrections. The model also has application as a near real-time, global ionospheric forecast model that could be run at AFSPC's 55 SWXS, who supplies DoD space environmental support, and at the civilian counterpart at NOAA's Space Environment Center. Additionally, the flexibility and computational speed of the model would allow a large number of users the ability to develop ionospheric tailored products for specific navigation and communication customers. It is envisioned that such an ionospheric assimilation model would be the Space Weather equivalent of the National Center for Environmental Prediction (NCEP) Numerical Weather Model which has hundreds of users and applications.

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KEYWORDS: HF radars, space weather, total electron content, electron density profiles, ionospheric assimilation model, ionsopheric specification and forecast

AF99-034 TITLE: Automated Adaptive Task Scheduling for Satellite Network Operations

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop adaptive algorithms and models for automated near optimal task scheduling of satellite network operations.

DESCRIPTION: Satellite network operations can be viewed as a network of satellites and ground stations which require frequent contact links between them for satellite tracking, maintenance, and data dissemination. Contact windows between a satellite and a ground station/satellite are temporal and location dependent. Scheduling of an optimal task sequence for assignment of network resources to meet concurrent contacts (via single beam and/or multiple beam antenna) and other operational requirements without violating temporal, compatibility and capacity constraints, is a complex problem. In addition, constraints, priority, mission requirements, resource availability and emergency requests are dynamic and vary between satellites. Current automated scheduling schemes are incapable of producing near optimal results in real-time for maximum network performance and resource utilization, resulting in costly and inefficient satellite operations. A solution for eliminating this deficiency is to develop adaptive scheduling algorithms capable of achieving optimal tasking order and resource assignment. Cost is then reduced through automation and efficient operations. The purpose of this research is to develop automated task scheduling algorithms that can adapt to changing rules, constraints and scenarios, and which react to provide dynamically updated schedules for satellite network operations. The algorithms would allow for human intervention for approval or override of the schedules generated. At least three algorithms that are intrinsically different in their technical approach should be developed and demonstrated. New and innovative or hybrid techniques with adaptive and learning capabilities should be considered. Potential new resource capabilities and operational concepts such as simultaneous multiple satellite links and distributed scheduling will be factored into algorithm design. Each candidate algorithm will be assessed in terms of the optimality of its scheduling results, computational efficiency, adaptability, response time, generality, testability, extensibility, and degree of human intervention required.

PHASE I: 1) Characterize the scheduling problem for satellite network operations; 2) develop a standard representation of all scheduling parameters, variables, priorities, rules and constraints that are required for input to scheduling algorithms; 3) specify a standard output of scheduling results; 4) formulate candidate adaptive scheduling algorithms which meet requirements as described above for single and/or multiple beam antenna; and 5) demonstrate prototype of each algorithm for a representative limited case.

PHASE II: 1) Construct a representative set of test input scenarios based on hypothetical and AF Satellite Control Network (AFSCN) scheduling requests and contact records; 2) code the candidate algorithms under a single simulated test environment; 3) experiment the algorithm driven by the test scenarios; 4) compare between the performance and efficiency of each candidate scheduling algorithm, the ROSE (Request-Oriented Scheduling Engine) and real AFSCN scheduling results; and 5) identify new technical issues related to the practicality of the candidate scheduling algorithms and additional technology needs.

PHASE III DUAL USE APPLICATIONS: The automated adaptive scheduling algorithms developed from this research are applicable to a wide range of military and commercial systems that require automated near optimal scheduling of service requests and allocating of shared resources in real time.

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KEYWORDS: adaptive, heuristics, near optimal, neural network, satellite network operations, automated dynamic scheduling

AF99-035 TITLE: High Bandwidth Photodetectors for Space Applications

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop a high bandwidth photoreceiver for satellite-based optical computing and optical interconnect data links in enhanced environments.

DESCRIPTION: Photoreceivers are among the least radiation-tolerant constituents in optical processors and interconnects. False bit detection, induced by ionizing radiation or the complete failure of receivers, will prevent optical processors or interconnects to be used reliably in space. Current research indicates that 10 GHz receivers are realizable. However, further developments in the design of radiation-tolerant receivers and so-called "Smart Pixels" that can operate as emitter, modulator and detector is required. An example of a promising technology that has an inherently high radiation tolerance through its design, is Fabry-Perot cavity-enhanced Multiple Quantum Well (MQW) structures that also meet anticipated low power requirements.
The photoreceivers should be capable of a bandwidth of 10 GHz or above, and should have a peak detection efficiency at 850 nm for optical processors or the onboard satellite data link, and 1550 nm for inter-satellite communication applications. Potentially suitable, monolithic photodetectors and smart pixels are already under development and may be readily adapted for this application. The final detector design, preferably a III-V detector material monolithically integrated with CMOS, should be capable of operating for a minimum of 10 years in low earth orbit at an inclination of 30 to 60 degrees with a bit error rate of 10(-10). Within this time frame, the detection efficiency should not drop below 50% of the pre-flight performance. If a monolithic design (detector plus driving circuitry) is chosen, both the detector and the driving circuitry is to be radiation tolerant at the above specifications.

PHASE I:Identify a suitable high bandwidth (|10 GHz) photoreceiver or smart pixel design concept. A suitable design has to be advanced to entail the complete growth sheet. The design has to be motivated by modeling the radiation response to ionizing radiation.

PHASE II:Working prototypes of the Phase I design are to be manufactured and evaluated for their speed and suitability for use in space-based application. A feasibility study has to demonstrate that this detector design can be manufactured within practicable costs.

PHASE III DUAL USE APPLICATIONS: Commercial and military space flight missions will rely more heavily on optical interconnects to reduce weight, increase data bandwidth, and reduce the power consumption if radiation-tolerant and reliable solutions have been demonstrated. In particular, laser-based inter-satellite communications will greatly benefit from these detector solutions.

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KEYWORDS: space, satellite, smart pixel, photoreceiver, high bandwidth, optoelectronics, radiation tolerant, optical interconnect

AF99-036 TITLE: High Accuracy, Automated Satellite Surveillance Network

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop automated network of Satellite Surveillance Sensors to produce high accuracy angular observations for use with a decentralized orbit determination system.

DESCRIPTION: Satellite operational systems often use control antennae and ranging observations, along with angle observations derived from the gimbal angles of their command, as input to their orbit determination. The range observations can be highly accurate and precise; the angle observations, however, usually lack precision due to their nature as measurements of large, mechanical gears. DoD/NASA/Commercial satellite owners have a myriad of reasons, including collision avoidance, to abate the errors in orbit determination and prediction. The addition of high precision angular observations to the orbit determination process can significantly improve the accuracy of both the orbit determination and subsequent prediction of orbital motion. A network of optical sensors, sharing observations in real time, is needed to provide an efficient and effective method for making high precision observations on satellites and disseminating those observations to orbit determination sites in a timely fashion. In order to obtain high quality orbit solutions from angular observations, the sensors must have a standard deviation of less than 0.5 arc second. The sensor must operate in a completely passive fashion. That is, satellites may not be actively illuminated by laser, nor are the satellites equipped with GPS receivers. The sensor can operate in a variety of climatic conditions, including desert and tropical. The sensor will include automatic weather monitoring equipment. Operation will be remote, with human intervention needed only in the case of hardware failure. Any image processing required to derive the angular observations will be executed in an automatic and timely manner. The sensor will require a minimum amount of infrastructure, and it will be rapidly deployable with total set up and configuration not to exceed 48 hours.

PHASE I: 1) Through cooperation with the Air Force, develop complete familiarity with current needs for high precision observations, 2) develop preliminary design of sensor network complete with documentation that will provide proof of functionality, and 3) produce and demonstrate a prototype to ensure proof of basic design concept.

PHASE II:1) Finalize the design of the sensor network, and 2) build and demonstrate a full-scale operational, prototype network consisting of at least two sensor sites fulfilling mutually agreed-upon Air Force specifications.

PHASE III DUAL USE APPLICATIONS: Development of an automatic sensor network producing high precision observations will spark high DoD/NASA/Commercial demand to increase orbit determination and prediction accuracies. Additionally, technical innovations derived from this effort will have high commercial appeal in the amateur astronomer market.

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KEYWORDS: astrometry, optical sensor, space surveillance, angles-only orbit determination, high precision orbit determination, autonomous satellite ground stations

AF99-037 TITLE: Computer Aided Design (CAD) for Rad-Tolerant, Rad-Hard Microcircuits

TECHNOLOGY AREA: Electronics

OBJECTIVE: Incorporate radiation hardening features into computer-aided semiconductor design tools.

DESCRIPTION: Presently, most semiconductor manufacturers rely on automated design tools to design advanced microelectronics; many also rely on such tools to develop improved semiconductor processes. Most custom semiconductor fabrication facilities expect customers to design their own devices and circuits (or have them designed elsewhere) using design tools; therefore, those facilities are equipped to import these designs. This approach is not presently possible for radiation-hardened microelectronics, since there is no publicly available set of semiconductor design rules that incorporate the features of radiation-hardened electronics. The objective of this project is to develop radiation-hardened design rules capable of being integrated into existing design tool systems or provide radiation-effects models that are compatible with the simulation portion of such tools. The purpose of the radiation-hardened design rules is to facilitate fabrication of radiation-hardened/radiation-tolerant microelectronic devices in commercial fabrication facilities. Developed capabilities will be sufficiently generic that they can be incorporated into a broad range of existing tools and will not rely on a specific manufacturer's design tool system.

PHASE I: 1) Through cooperation with the Air Force, develop complete familiarity with current needs for radiation-hardened design rules. 2) Develop preliminary design of radiation-hardened design rules complete with documentation that will provide proof of functionality and integration capability. 3) Demonstrate mutually agreed-upon key elements of the radiation hardening features that can be incorporated into design tool systems.

PHASE II:1) Finalize design of the radiation-hardened design rules. 2) Demonstrate integration capability of the radiation-hardened design rules into at least two current (mutually agreed-upon) existing design tool systems.

PHASE III DUAL USE APPLICATIONS: This capability would increase the availability of radiation-tolerant electronics and would reduce their cost. This technology would be used by a large number of DoD, as well as other government and commercial space system developers.

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KEYWORDS: microcircuits, integrated circuit, radiation-hardened, radiation-tolerant, single-event phenomena, space-qualified electronics

AF99-038 TITLE: Advanced Nonlinear Adaptive Controllers for Fault Tolerant Satellite Trajectory Control

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop an adaptive (neural network or fuzzy logic-based) controller for use with or instead of a conventional controller for satellite maneuvers.

DESCRIPTION: With the current requirements to: 1) increase performance of satellites, 2) guarantee stability, 3) reduce the cost of operations, controller design, synthesis and testing, and 4) to provide for the ability to recover safely from non-catastrophic system failures, it is essential to develop control algorithms and strategies with significant inherent robustness and only nominal dependence on fixed (linear or nonlinear) mathematical models. These algorithms must be developed such that a high level of performance is achievable even with modeling uncertainties, changes in the system dynamics, and common classes of system failures. The issue of implementability based on available hardware must be convincingly addressed. Furthermore, it must be demonstrated that the design, synthesis, and test phase is shorter and less costly than that of conventional methodologies, and that the achievable performance, on-orbit, is better than that of the conventional algorithms.

PHASE I: 1) Develop necessary adaptive control algorithms and generic adaptive satellite controller. 2) Demonstrate the feasibility of using the adaptive controller, desirably neural network or fuzzy logic-based, for advanced satellite maneuvers. 3) Compare the performance of the conventional and adaptive controller on a generic satellite model with known system dynamics. 4) In conjunction with the Air Force, select a specific satellite system (with an imaging system or space-based laser on board) for further development in Phase II.

PHASE II:1) Develop and demonstrate an adaptive controller for the specific satellite system chosen in Phase I. 2) In conjunction with the Air Force, perform an on-orbit flight demonstration on any applicable satellite, perhaps an AFRL MightySat series satellite or a NASA New Millenium Program satellite.

PHASE III DUAL USE APPLICATIONS: Military Application-This approach will be essential to many future military satellite programs because of the high accuracy and high slew rate performance it enables, as well as because of the enhanced survivability that is due to the capability for high levels of performance and stability in the face of non-catastrophic failures. Commercial application-This approach for the design of spacecraft guidance and control systems has tremendous potential because the controller can be applied to large numbers of spacecraft (either of the same type or large classes of different spacecraft), and will have the capability to adapt to a bounded class of variations in the dynamics. In addition, the approach eliminates requirements for a significant amount of on-orbit tuning or trial and error adjustments. This will tremendously reduce cost compared to current approaches.

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KEYWORDS: fuzzy logic, neural network, system dynamics, control algorithms, satellite maneuvers, adaptive controller

AF99-039 TITLE: Use of Plastic Encapsulated Microcircuits as Space Qualified Components

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop test procedures and acceptance/rejection criteria for use of Plastic Encapsulated Microcircuits (PEMs) in space.

DESCRIPTION: Although hermetically sealed microcircuits, such as ceramics, have been used successfully in space, there is a potential cost savings if Plastic Encapsulated Microcircuits (PEMs) packaging is used. PEMs are used in packaging over 85% of commercial integrated circuits. Among the possible benefits in using the commercial off the shelf PEM components are: reduced

costs/weight, greater availability, decreased size, and access to a commercially developed, enhanced, and on-going improvement process for packaging. On the other hand, while PEMs have been considered for use in space for over a decade, there are some possible obstacles that must be addressed. These include: a) non-hermetic seals, b) outgassing, c) possible degradation due to long-term storage and "non-operating" conditions, d) narrow temperature range, e) package cracking "popcorn effect") during board assembly, and f) not fully characterized radiation hardness. The goal of this project is to develop a test methodology which will qualify PEMs for use in space. PEM parts selected as candidates for space qualification, must conform to existing functional requirements/standards. The project should address various configurations of commercially available PEMs (quad flat packs, ball grid arrays, and other relevant styles). An outcome of this activity (based on actual testing of commercial microelectronic components) would be to build a database from which a set of guidelines may be developed for the use of PEMs in space applications. Test methodology would include statistical quality control methods as well as 100% screen tests and lot conformance tests. The tests must cover a temperature cycling range from -55 degrees C to +125 degrees C, radiation hardness tests covering the range from 100 krad to 1 Mrad, and HAST at 131degrees C for 100 hours. Consultation with existing laboratories which have already begun work in this arena (the PEM community, "PEMC", such as NASA, Rome Lab., commercial companies, the University of Maryland, etc.) as to test procedures and test results required to build consensus and credibility, is strongly advised. Final project results will specify the characteristics for which measurements are needed, the acceptance/rejection range of values, and an estimate of reliability.

PHASE I: 1) Evaluate the relevance to military use of PEMs in space (communicate/coordinate with the PEMC), 2) determine/develop the test parameters/procedures required to be used to satisfactorily/credibly characterize the PEM performance, together with an initial set of acceptance/rejection criteria, 3) test PEMC acceptance of the test plan/criteria and appropriately revise, and 4) define a detailed Phase II test plan together with identification of a set of candidate PEM parts to use in the testing to be done in Phase II.

PHASE II:1) Based on the test procedure framework developed in Phase I, perform tests on the selected parts and characterize their performance, 2) based on the test results, develop acceptance/rejection criteria for use of PEMs in the space environment, and 3) build a database of test procedures/results covering both those which do and do not provide the assessment needed.

PHASE III DUAL USE APPLICATIONS: These procedures would make it possible to use commercial parts in space for both military and commercial applications. With the large number of commercial communications satellites being planned and launched, this project could provide a source of significant cost avoidance.

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3. Clark, Steven D. et al., Plastic Packaging and Burn-in Effects on Ionizing Dose Response in CMOS Microcircuits, IEEE Transactions on Nuclear Science, Vol. 42, No. 6, December 1995
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KEYWORDS: outgassing, hermeticity, package cracking, radiation hardness, non-destructive inspection, hermetically sealed microcircuits, plastic encapsulated microcircuits (PEMs)

AF99-040 TITLE: Visible Sensor Discrimination Utility and Intersatellite Fusion of Discriminants

TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop visible sensor logic for distant object extrapolation and effective discriminant data fusion methods amongst a satellite constellation.

DESCRIPTION: Advanced visible sensing and detection algorithms are applied in such global uses as military and commercial space-based terrain monitoring and event/object identification. Advances in sensor technology have lead to the need for development of visible discrimination fusion algorithms to aide in sensor detection and identification of distant objects and scenarios which may be observed in the visible spectrum. Specifically, development of intersatellite discriminant fusion methods will significantly improve ways in which different satellites view/obtain and fuse information from the same object or signal obtained from different perspectives. The objective of intersatellite discriminant fusion methods is to allow sensors to make sense of the same data from different viewing angles, sides, etc. by fusing the information into a concise picture which provides a more robust object profile/data

file by compiling the various observation points. Currently, utilization of Low Earth Orbit (LEO) constellations is growing as communications companies use these constellations as a means of providing near-term improved communications. Future advances in commercial communications, and particularly in sensor applications, will necessitate the fusion of the same data, perceived amongst several satellites in a LEO constellation, from different perspectives. From a military point of view, the need for intersatellite discriminant fusion methods is based on the need to identify a target or re-entry vehicle and to successfully fuse the different aspects of data gathered on these objects to provide a more robust picture as well as a higher level of confidence in identifying the object at hand.

PHASE I: With Air Force assistance: 1) Review current visible sensing/detection algorithms and event/object identification methodology; 2) develop prototype discriminant fusion algorithms/system methodology, designed to resolve multiple perceptions of the same image; 3) identify/develop simulated visible signatures (events/objects) which can be used to test discriminant fusion algorithms; and 4) demonstrate (mutually agreed-upon) key elements of the discriminant fusion system methodology.

PHASE II: 1) Finalize development of the discriminant fusion algorithms and system methodology, and 2) provide proof-of-concept demonstration of discriminant fusion system methodology (to Air Force and contractor mutually agreed-upon specifications and operational environment).

PHASE III DUAL USE APPLICATIONS: Several computer, telephone, and other communications companies are developing LEO constellations to enhance communications capability in the near future. The eventual need for these companies to resolve objects and/or information gathered from the various positions of several LEO satellites will require the resolution and integration capabilities of the algorithms/methodology developed in this project.

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KEYWORDS: midcourse tracking, optical algorithms, algorithm development, space-based visible sensing, space-based terrain monitoring, space-based object discrimination

AF99-041 TITLE: New, Innovative Battery Charge Control System

TECHNOLOGY AREA: Electronics

OBJECTIVE: Extend life of solar-charged space batteries by optimizing the charging system.

DESCRIPTION: Orbiting satellites require a constant power source to operate effectively. While in direct sunlight, satellites are able to harvest the sun's energy via solar cells. However, when the satellite is in the Earth's shadow, there is no direct sunlight, and the satellite has to rely on internal energy to continue its mission. This internal energy is provided by secondary electrochemical batteries. Secondary batteries store the surplus energy generated by spacecraft solar arrays. Since each type of battery's life span can be optimized by following a precise charging pattern, there is a continuing need to improve the battery charging profile. Proposals relating to optimized charging profile of existing batteries and/or proposals relating to new battery technology and associated optimum charging strategy are solicited.

PHASE I: Utilizing Air Force input, identify future power requirements and power consumption profiles for a specific communications satellite-related mission. Identify one or two battery types that are most likely to be used in the mission. Based on the power consumption profile, and the cyclic current generation characteristics of the solar array over the course of the orbit, explore battery configurations and charging strategy to maximize the useful life of the satellite. Design/develop a prototype optimum battery charging system. Provide breadboard demonstration of life expectancy resulting from optimized battery/battery charging profile.

PHASE II: Finalize design/construct an optimized battery/battery charging system which provides an optimal system level solution to the cyclic current generating characteristics of solar arrays and the optimum charging requirements of satellite batteries. Assess the "quality" of power and the reliability of the final product in a simulated "space environment" demonstration of the optimized battery/charging system.

PHASE III DUAL USE APPLICATIONS: Commercial and military satellite operational life will benefit from successful research and development in this area. Optimized battery charging strategies (which extend battery life and operation) are applicable to a myriad of battery operated equipment.

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1. R. Graf, The Modern Power Supply and Battery Charger Circuit Encyclopedia, McGraw Hill, 1992.
2. P. Horowitz and W. Hill, The Art of Electronics, Cambridge University Press, 1989.

KEYWORDS: solar arrays, constant power, satellite battery, battery charging profile, power consumption profile, secondary electrochemical battery

AF99-042 TITLE: Magnetic Device Design for High Temperature, High Performance Applications

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Develop new high temperature magnetic device performance models based upon device excitation/thermal conditions.

DESCRIPTION: The design of high frequency, high performance magnetic components for the next generation power systems depends upon accurate modeling of magnetic core losses and other operational parameters as a function of thermal/electrical environment. For instance, the use of high temperature silicon carbide transistor switching devices will significantly impact the design of ferrite core magnetic components of the switch. Historically, magnetic device design has been based upon vendor-published performance data and empirically determined thermal design guidelines. As operating temperature, packaging densities and thermal management techniques change, these traditional sources of design information are no longer adequate. A pervasive need exists to develop design criteria and performance models for advanced, high performance, magnetic component-centered devices based upon accurate material characterization and integrated thermal/electrical design data. One approach to the problem (among others) would be to develop test procedures (and associated test equipment) to evaluate magnetic material/component performance as a function of excitation conditions resulting from frequency variation, waveform configuration, duty cycle, environmental/operating temperature, thermal management strategies, wire winding/interconnection configurations, etc. Based upon the inputs that will result from the test procedures previously developed, construct a model/simulation program capable of generating the desired design data. This model would then be validated utilizing test results/data from a test program structured on the test procedures previously generated. Typical design data include (among others) frequency/power-dependent hysteresis curves and transfer functions based upon the magnetic material and upon selected power system related magnetic component configurations (designed and/or acquired from several component suppliers). Magnetic component test configurations shall utilize several different materials and construction techniques. Frequency ranges of up to 5 MHz, power levels of one KW and greater at 70-120 Volts primary, together with 3X transients up to 360 Volts and temperature ranges up to the Curie Point of the material being tested, are to be considered.

PHASE I: Activity shall include: 1) select/design detailed test procedures/test equipment required to evaluate magnetic component performance, 2) develop detailed flow chart/preliminary design of model/simulation program capable of generating desired design data, 3) complete draft of design model and provide demonstration of basic model capability, 4) develop detailed Phase II test plan to generate test data and validate design/simulation model, and 5) design/select magnetic component test configurations.

PHASE II:1) Acquire/design and construct test equipment, acquire magnetic test components and perform test plan, 2) finalize simulation model and perform validation tests of design model utilizing data acquired from test plan, 3) modify design/simulation model, if required, and 4) document design parameters over range of conditions investigated within test plan.

PHASE III DUAL USE APPLICATIONS: Successful development of a design/simulation model and publication of design parameters for power system-related, high temperature magnetic components will be of high interest/demand to both DoD and commercial electrical equipment manufacturers.

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1. J.J. Rousseau, et. al., A Complete Hysteresis Model for Soft Ferrites Taking Into Account the Temperature, 1996 IEEE PESC proceedings pp 322-328.
2. F. Tan, et. al., A Practical Approach for Magnetic Core-Loss Characterization, IEEE APEC proceedings, pp 572-578.

KEYWORDS: power systems, packaging density, performance/simulation models, thermal/electrical environment, high temperature transister switch, high temperature magnetic components

AF99-043 TITLE: Development of a Laser-Based Single Event Effect Probe Station

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop a compact laser-based single event effect probe station for use in microelectronic design and test.

DESCRIPTION: Laser-based testing of microelectronic components for susceptibility to single event effects (SEE) is a viable alternative to particle-beam testing for screening of parts as an element of the hardness assurance process. However, laser-based testing to date has been confined to utilization of expensive optical table-top systems and has been primarily employed for research. This proposal envisions the development of a diode laser-based SEE probe station which could be used by the microelectronic designer and test engineer. The probe station would be compact and would ideally be designed to facilitate wafer-probe evaluation of parts, a task which is impractical with current systems. The probe station shall be constructed to hold a solid state laser or other compact and vibration insensitive lasers and shall focus the laser beam onto the device under test (DUT). The microscope setup would be mounted on a two-dimensional translation stage with sub-micron spatial resolution that would move the diode laser, focusing optics, and associated apparatus through at least one inch of travel in orthogonal directions in the plane of the DUT. Ideally, the probe station would be modular so that various lasers could be used as needed to take advantage of different laser wavelengths. Simulation of single event phenomena will require laser pulses shorter than 50 psec in duration. The exact pulsewidth required is unknown; however, typical research facilities use pulses of 20 psec or less. Lasers with wavelengths in both the 600-650 nm and 800-900 nm ranges are desirable. Pulse energies should exceed 0.1 nJ. Pulse repetition rates should range from single shot to a few hundred hertz. The microscope would contain a zoom lens device in order to focus and control the laser spot size in the plane of the DUT. Spot sizes from 200 microns down to 1-2 microns would be desirable. This spot size requirement assumes a Gaussian shaped pulse with the designated spot sizes at the 1/e diameter of the intensity. The microscope system would also contain two additional ports: one to allow injection of white light to illuminate the region under test, and the other to allow imaging of the device under test using a CCD (charge coupled diode) camera system. The microscope-laser assembly should be compact and designed to be integrated with a standard microelectronics wafer probe station.

PHASE I: Perform the layout and design of the SEE test module. This would include: 1) mechanical layout and design; 2) optical CAD, including optical propagation analysis to ensure small laser spot size on the sample as well as the integration of the white light source and imaging system; and 3) analysis of the interface requirements to integrate the laser assembly into a standard microelectronic test station.

PHASE II: 1) Develop a prototype of the laser SEE test module and demonstrate its integration into a standard microelectronic probe station. 2) Perform tests on standard devices (e. g., SRAMs) to validate the system performance.

PHASE III DUAL USE APPLICATIONS: The system would benefit design and test engineers in the defense industry as well as those in commercial industries who are concerned about SEE and want to incorporate SEE test results into the design process at an early stage. SEE affects microelectronics for avionics as well as spacecraft. SEE are also of concern to designers of memory devices such as SRAMs (static random access memory) and DRAMs (dynamic random access memory), which may be susceptible to soft errors induced by radioactive decay in the natural terrestrial environment or by cosmic rays. The SEE test system would also have potential applications for testing charge-coupled device imaging sensors, as well as other imaging sensors, by allowing charge to be generated within a single pixel or within multiple pixels. This would be of use for evaluating fill factor or charge transfer efficiency in devices used as star trackers, or in medical, dental, and other imaging applications. There are also other potential medical applications, such as scanning of the cornea to determine its curvature, or scanning portions of the retina to examine the localized health of the rods and cones.

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KEYWORDS: microelectronics, radiation effects, hardness assurance, single event effects, laser based SEE probe, particle beam testing, microelectronics wafer probe

AF99-044 TITLE: Methods to Characterize and Qualify Thick-Film SOI Wafers

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop methods to characterize and qualify thick-film SOI starting material.

DESCRIPTION: Thick-film (greater than 1 micrometer) Silicon-On-Insulator (SOI) wafers are now being used to manufacture a variety of electronic products with advanced features, such as analog integrated circuits that have improved accuracy, digital integrated circuits that operate at higher frequency and lower power, high voltage devices that are monolithically integrated with signal processors, and micromachined sensors that offer higher precision, increased reliability, reduced size/weight, and lower cost. One of the problems encountered in manufacturing these SOI products, however, is that many of the metrology techniques and instruments needed to characterize and qualify the SOI starting wafers are lacking. Technology/processes/equipment are urgently needed to verify/characterize such basic properties as: 1) the thickness of the silicon film and the buried insulating layer (these values cannot generally be measured quickly and accurately, especially for silicon films thicker than about 10 micrometers); 2) the integrity of the silicon film to insulating layer bond interface (at which microvoids and contamination are both important and difficult to measure); 3) the resistivity and defect density of the silicon film; 4) the density and charge trapping properties of the buried oxide; and 5) the presence and concentration of contaminants, such as oxygen, carbon, and heavy metals. Because of the way bonded wafers are now manufactured, a cassette of finished wafers may contain material from different silicon crystals, and these wafers may have been oxidized, bonded, ground, and polished at different times, or even using different pieces of equipment. This precludes the use of lot sampling methods to qualify the material, making it imperative that the characterization tests that are proposed be cost effective, possess timely on-line capability, and be non-destructive. Examples of non-destructive test methods include, but should not be limited to, optical, x-ray, acoustical, and non-contact-electrical.

PHASE I: 1) Define and evaluate one or more of the measurement techniques identified in the topic Description (above); 2) based on the evaluation data, select one, or more, techniques and identify/develop required technology/processes/equipment to the extent that will allow a demonstration of key elements of the measurement technology; and 3) provide a demonstration of key elements of the selected technology(s) to provide confidence in the success of the Phase II effort.

PHASE II:1) Finalize the measurement technology(s) demonstrated in Phase I, 2) design/procure/fabricate required production prototype equipment, 3) accurately define and implement process parameters/ procedures/documentation of results and finalize any required software, and 4) provide a statistically valid demonstration of the validity of the selected measurement technology(s).

PHASE III DUAL USE APPLICATIONS: Commercial products based on thick-film SOI are now in early production. Many of these products are of high interest to DoD/commercial arenas, as is evidenced by the recent invocation of Title III of the Defense Production Act to ensure an on-shore thick-film SOI supplier. Thus, the market for the proposed characterization system would include the thick-film SOI wafer manufacturers, commercial users of these wafers, and the government.

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KEYWORDS: bonded wafers, semiconductors, integrated circuits, silicon-on-insulator, dielectric isolation, micromachined sensors

AF99-045 TITLE: Digital Signal Processing Circuit with Embedded Reprogrammable Nonvolatile Memory

TECHNOLOGY AREA: Electronics

OBJECTIVE: Integrate digital signal processing circuits with reprogrammable non-volatile memory to achieve field reprogramming capability.

DESCRIPTION: Digital signal processing (DSP) circuits are often used in advanced communication systems for noise suppression and signal extraction. The functionality of a DSP circuit is customized and tailored by software to suit the task. The codes are normally stored in electronic memory. Read-only memories (ROMs) are preferred because they are non-volatile. However, the use of ROMs makes it difficult to reprogram the functionality of the circuit. Embedding reprogrammable nonvolatile memory integrated

with a high performance DSP circuit, fabricated with Silicon-On-Insulator (SOI) complimentary metal-oxide semiconductor (CMOS) technology, would eliminate the need for ROM, and support reprogramming in the field. The reprogrammable nonvolatile memory could retain data indefinitely without power being applied, and would, ideally, have the additional advantage of being radiation hard. A potentially lucrative, commercial need exists to develop cost effective methodology to inject reprogrammable nonvolatile technology into DSP circuits. The added flexibility of field reprogrammability would extend future mission capability of a myriad of military and commercial systems.

PHASE I: 1) Investigate design architecture trade-offs and process integration issues concerned with embedding reprogrammable nonvolatile memory in DSP circuits, 2) develop preliminary design for reprogrammable nonvolatile memory embedded DSP circuits, 3) develop prototype fabrication process for production of reprogrammable nonvolatile memory embedded DSP circuits, and 4) fabricate and demonstrate basic circuit.

PHASE II:1) Finalize basic design of DSP circuits with embedded reprogrammable nonvolatile memory, 2) finalize production process, and 3) fabricate and test (mutually agreed-upon) reprogrammable nonvolatile memory embedded DSP circuits.

PHASE III DUAL USE APPLICATIONS: DSP circuits are commonly used in a number of military and consumer applications, such as video and audio communication, image processing, radar, sonar signal processing, or graphics and scientific data analysis. Having the option of reprogrammability would render the circuit "smarter and friendlier" and would enable development of new applications in multiple areas, such as artificial intelligence, virtual reality, robotics, and all types of control systems, to name only a few.

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KEYWORDS: radiation hard, non-volatile memory, field reprogrammability, read only memories (ROMs), digital signal processing (DSP), magnetoresistive random access memory (MRAM)

AF99-046 TITLE: Solid-State Power Amplifier Modules for Wideband (L-Ku) Array Antennas

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop wide-band microwave solid-state power amplifier modules that demonstrate highly efficient performance in multicarrier applications for spaceborne phased array transmit antennas.

DESCRIPTION: This project addresses a common, space-related, DoD/commercial need: namely, to develop a method/device to simultaneously handle several carriers--in solid-state power amplifier chains widely separated in frequency--while reducing the intermodulation products to acceptable levels. A stepwise approach (among others) is envisioned. Initially, microwave integrated circuit (MIC) structured discrete devices will be used to demonstrate how to achieve the required performance; the design will then be transitioned to microwave monolithic integrated circuit (MMIC) technology to show compatibility with the current modules being considered for phased arrays. The power output of the test modules should be between two and three watts with a quiescent power of approximately ten milliwatts. The future application for these devices will be for military satellites as well as commercial satellites operating in X-band. Since multiple modulated carriers will be applied to the modules, the reduction of intermodulation products is one of the key issues. Potential voltage peaks that could cause device degradation as a consequence of beat frequencies is one of the reliability issues. Compensation techniques will be required to meet performance goals. The compensation techniques to be considered include, but are not limited to, the following: 1) automatic gain and level control to maximize efficiency with minimum intermodulation products, 2) a predistortion network to improve linearity and phase matching, 3) wideband characteristics to enhance phase matching, and 4) temperature compensation circuits.

PHASE I: 1) With the concurrence/assistance of the government sponsor, review/specify the requirements that meet the potential uses in both military and commercial communication systems, 2) determine/design/model approaches to meet the identified requirements, and 3) demonstrate mutually agreed-to key elements of the selected design to provide proof-of-design concept.

PHASE II:1) Fabricate hardware and perform adequate testing to demonstrate that significant improvement has been achieved in amplifier performance with regard to efficiency, linearity, phase matching, temperature stability, and reliability through the use of compensating circuitry. 2) The concept should be demonstrated first in MIC structures, and then transitioned to MMIC technology in order to show compatibility with current module developments.

PHASE III DUAL USE APPLICATIONS: Phased arrays are receiving considerable attention in both the military and commercial space communications and radar communities. Accordingly, the effort proposed is directly applicable to many systems under serious

consideration for future deployment that involve multiple carrier transmission and in which the reduction of intermodulation products is a key requirement.

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KEYWORDS: linearity, phase matching, beat frequencies, wideband characteristics, intermodulation products, multiple modulated carrier, microwave solid-state power amplifier, microwave monolithic integrated circuits

AF99-047 TITLE: Integrated Bilateral Electronic Components Technology for Spaceworthy Multi-Chip Modules

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop techniques to allow bilateral, passive components (resistors, capacitors, inductors, transformers) to be integrated in the multi-chip module fabrication process.

DESCRIPTION: Passive electrical components are a part of every electronics assembly. Significant success has been achieved in massive integration of active components (e.g., transistors, diodes) into integrated circuits. Passive components, however, are more than often attached discretely to the next level of assembly, whether a hybrid, multi-chip module (MCM) or printed wiring board. Specialized, low-profile resistor and capacitor components have been traditionally employed in hybrids and MCMs. However, these components and the labor associated with inserting them into an MCM is significant. Even in highly automated assembly operations, the expense of inserting passive components is greater than that of the components themselves. This problem will be exacerbated as more designs migrate from discrete analog and mixed signal assemblies to MCM form. By incorporating the components into the MCM fabrication process directly, the expense of procuring, screening, and assembling dozens of components is practically eliminated. Furthermore, integral components will provide for a greater overall substrate efficiency, resulting in smaller, more efficient, and more reliable MCMs. The net benefit to military/commercial space systems is a reduction in size, weight, power, and cost, with a collateral benefit in improved performance, particularly in mixed signal systems which often require complex networks of these components. The objective of this project is to develop innovative technologies to allow integration of bilateral, passive components in the MCM fabrication process. The preferred technique is one which will allow formation/integration of these components within the interconnection system itself and will be applicable and transferable to high performance polymeric-based MCM technologies. Alternately, but less desirable, are approaches that depend on a particular type of substrate. Of least interest (but an acceptable approach) is the development of a new, unique MCM technology. Component electrical quality is of primary concern, as is the ability to closely and repeatably form these components to a degree of precision adequate for analog instrumentation and signal processing applications.

PHASE I: 1) Through cooperation with the Air Force, develop complete familiarity with current needs for integration of bilateral, passive components in MCM modules, 2) develop preliminary design of integration technique, complete with documentation that will provide proof of functionality, and 3) produce and demonstrate a prototype to ensure proof of basic integration concept.

PHASE II:1) Finalize integration technique design, 2) build a full-scale operational, prototype integration process facility, and 3) produce/demonstrate prototype MCM modules containing integral passive components to agreed-upon Air Force specifications.

PHASE III DUAL USE APPLICATIONS: The results of a successful Phase II approach would lead to a superior integrated passive circuit technology that could be transferred to a number of candidate MCM approaches that will spark high DoD/NASA/Commercial desire to achieve reduction in size, weight, power, and cost, with a collateral benefit in improved performance for space-based applications.

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KEYWORDS: resistors, capacitors, multi-chip modules, integrated circuits, electronics packaging, mixed-signal technology

AF99-048 TITLE: SEU-Tolerant Low-Voltage CMOS Technology

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop a technique for ensuring the single-event upset hardness of low-voltage CMOS technology.

DESCRIPTION: The use of CMOS (complimentary metal oxide semiconductor) technologies at voltages at or below 1V would allow substantial reductions in power requirements for space systems. Currently space systems operate at 5V or higher, with a trend to 3.3V. Reducing operating voltages below 1V would dramatically reduce the power system weight and size, and would lead to the early development and deployment of microsatellite systems. However, reduced supply voltages are usually accompanied by an undesirable reduction in speed performance, radiation tolerance, and noise margin. In particular, single event hardness degrades substantially as the supply voltage is lowered, because the reduced total charge stored at floating nodes is more easily upset. This investigation would define a framework for utilizing CMOS technologies to operate at voltages below 1V without sacrificing SEU (single event upset) hardness.

PHASE I: Develop and demonstrate a circuit architecture, targeted to one or more specific CMOS processes, that will exhibit a single event upset rate less than 1 x 10(-8) error per bit per day or 1 x 10(-8) error per gate per day in the Adams 90% worst-case environment, when operated at or below 1V.

PHASE II:Design/construct a sample circuit such as a SRAM (static random access memory), a latched shift register, or a microprocessor, utilizing the architecture and technology developed in Phase I. Demonstrate that the circuit's single event upset tolerance meets the requirements defined in Phase I when operated at or below 1V.

PHASE III DUAL USE APPLICATIONS: The development of an SEU tolerant low-voltage CMOS technology would benefit both military and commercial satellite systems. In addition, the results of this effort may also be applied to improving single event upset hardness in advanced ground-based commercial products due to susceptibility to cosmic particles and radioactive contaminants.

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KEYWORDS: low-voltage, noise margin, space systems, speed performance, radiation tolerant, SEU (single event upset)-tolerant, CMOS (complementary metal oxide semiconductor) technology

AF99-049 TITLE: Hardened VHSIC Hardware Description Language Digital Signal Processing Module Generator

TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Enable designers of hardened DSP Application Specific Integrated Circuits to create blocks of DSP datapath logic using VHDL-based tools.

DESCRIPTION: Very High Speed Integrated Circuit Hardware Description Language (VHDL) is an IEEE standard language for the definition of digital systems. Many commercial design tools are available for building VHDL descriptions and creating their associated physical layouts. These commercial tools are generally targeted to support Application Specific Integrated Circuit (ASIC) implementations in commercial foundry processes, and not radiation-hardened foundry processes. A current Air Force need exists to develop a generalized VHDL Digital Signal Processing (DSP) module generator targeted to radiation hard foundries and critical space satellite applications with operating clock frequencies greater than 100MHz. The VHDL DSP module generator is to be developed for use in relation to custom Very Large Scale Integrated (VLSI) circuit designs implementing hardware DSP functions. Integral to the VHDL DSP module generator shall be a set of parameterized DSP "modules" that implement dedicated DSP functions

and may include: Fast Accumulator, Array Multiplier, Finite Impulse Response Filter, Fast Fourier Transform, Digital Correlator, Histograming Memory, Numerically Controlled Oscillator, and Digital Down Converter. User-defined parameters shall include, but not be limited to: control signal polarities, datapath width, and speed vs. area. The DSP module generator shall be capable of targeting an associated radiation-hardened ASIC parts supplier's library, automatically creating a VHDL model of the DSP function and creating a correct-by-design physical layout of the DSP function. A proof-of-concept demonstration of the overall software design shall entail 1) creating a graphical user interface-based generator of selected DSP "modules" (selected through joint Air Force/contractor agreement), 2) targeting a radiation-hardened library from one or more radiation-hardened parts suppliers, 3) automatically generating the modules' associated VHDL design information, 4) automatically generating the modules' associated physical layout, and 5) demonstrating the simulation fidelity between physically extracted timing data versus generated VHDL module timing data.

PHASE I: Activity shall include (but not be limited to): 1) identification of a candidate set of parameterized, VHDL DSP generator "modules", 2) design of a comprehensive overall system level, 3) demonstration of VHDL DSP module generator integration with existing Electronic Design Automation (EDA) ASIC design flow, and 4) an Air Force/contractor agreed-upon preliminary demonstration of system building blocks.

PHASE II:Activity shall include (but not be limited to) 1) completion of the VHDL-based radiation hardened DSP module generator software system, 2) fabrication of the generated DSP modules for use in the demonstration of the simulation fidelity between physically measured timing data versus generated VHDL module timing data, and 3) full-scale demonstration of the system in accordance with the above (Description Section) requirements.

PHASE III DUAL USE APPLICATIONS: VHDL is emerging as an industry standard input description language of simulation and synthesis of ASIC designs. Successful development of a radiation-hardened VHDL-based DSP module generator, consisting of functions, possibly with different implementation, will have extensive application in the design of both DoD and commercial space-based digital signal processing equipment telephony, communications and resource imaging.

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1. J.S. Calhoun, V.K. Madisetti, R.B. Reese, and T. Egolf, Developing and Distributing Component-Level VHDL Models, Journal of VLSI Signal Processing 15, pp111-126, 1996.
2. C. Meyers, R. Dreiling, VHDL Modeling for Signal Processor Development, Proceedings of the 1995 20th International Conference on Acoustics, Speech, and Signal Processing (Part 4 of 5), pp. 2699-2702, 1995.
3. C. Deltoso et. al, Fast Prototyping Based on Generic and Synthesizable VHDL Models. A Case Study: Punctured Viterbi Decoders, Proceedings of the Seventh IEEE International Rapid System Prototyping Conference, pp.158-163, 1996.

KEYWORDS: ASIC design, rad hard VLSI, automated IC layout, ASIC module generator, digital signal processing, automated VHDL generation

AF99-051 TITLE: Satellite Vehicle Tracking via S-Band Maser and Adaptive Optics

TECHNOLOGY AREA: Sensors

OBJECTIVE: Create tunable S-Band maser to enhance satellite vehicle tracking accuracy.

DESCRIPTION: Current Air Force Satellite Control Network (AFSCN) satellite vehicle tracking is accomplished using two-way S-Band communication links between parabolic ground antennas and satellite vehicles. Two inherent weaknesses of the parabolic antennas with respect to satellite vehicle tracking are 1) the relatively large angular spread of the main beam lobe at S-Band frequency, and 2) the existence of significant side lobes at S-Band frequency. Both of these weaknesses can, and sometimes do, negatively impact satellite vehicle tracking accuracy, especially if the satellite vehicle's transponder is down. Both of these weaknesses are caused by the physics of electromagnetic waves and parabolic antennas. A tunable S-Band maser beam addresses both of the weaknesses of parabolic antennas, because the maser's main beam width depends on the size and shape of the resonant cavity, and no side bands of any consequence exist. Laser technology has matured to the point where some manufacturing techniques and control systems could possibly be migrated to maser systems (e.g., tunable lasing systems, low flutter, low drift, low power, high temporal and spatial coherence). By supplementing a parabolic antenna with an S-Band maser, a ground antenna site would be able to accurately track anomalous or "silent" satellite vehicles. Also, an S-Band maser would be able to deliver a signal with high EIRP to a satellite vehicle without blanketing the surrounding area with side lobe radiation, as a parabolic antenna does.

PHASE I: Setup and test an S-Band maser prototype using COTS equipment. The maser should be tunable through the entire S-Band in order to be fully compatible with AFSCN-supported satellite vehicles, and the maser pointing system should be compatible with current AFSCN "antenna pointing angle" input signals. Phase I also includes experimentation of adaptive optics concepts into the S-Band region. Optical phase conjugation, phase conjugation mirrors, and atmospheric distortion compensation should attempt to be migrated from current laser technology to maser technology.

PHASE II:Create a powerful (> 0.5 kilowatt) proof-of-concept S-Band maser equipped with at least one adaptive optics capability (migrated from laser adaptive optics in Phase I). The Phase II maser would be tested by being slaved to an existing tracking antenna and illuminating an existing satellite vehicle to determine if a significant increase in range/range rate accuracy can be demonstrated. Range and range rate tests should include one-way (passive satellite vehicle) and two-way (active satellite vehicle transponder) measurements in order to measure differences between the tracking processes.

PHASE III DUAL USE APPLICATIONS: S-Band masers have the desirable characteristics of spectral purity, relatively tight beamwidth, high EIRP for relatively low power input, and minimal weather distortion. Commercial and military satellite vehicle operators will be needing these characteristics in order to maximize capability and minimize cost of their ground systems.

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2. Zeldovich, Boris, "Optical Phase Conjugation", Scientific American, Vol 253, No. 12, pp. 54-59, Dec 1985.
3. Zeldovich, Boris, "Principles of Phase Conjugation", Springer-Verlag, 1985.

KEYWORDS: maser, S-band, adaptive optics, optical phase conjugation, phase conjugation mirrors, satellite vehicle tracking, atmospheric distortion compensation

AF99-052 TITLE: Method for Near Optimal Antenna Placement for Satellite Operations

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop methods for optimal placement of antennas/ground stations against given satellite operation requirements.

DESCRIPTION: Antennas are used by satellites to provide communication between satellites in orbit and ground stations for the purpose of satellite tracking, maintenance, and dissemination of payload data. These ground stations are major contributors to the overall cost of satellite control networks. Part of the solution to reduce the high cost of satellite network operations is to optimally place ground antennas for minimal number of antennas and ground stations while still meeting the required level of satellite support. However, there has been very little open research in determining an optimal placement of antennas/ground stations for concurrent multiple satellite operations while satisfying many constraints in temporal and location dependency, priority, criticality and other resource scheduling factors. It is a very complex nonlinear global minimization problem with many operating constraints and there is no known analytical method to provide an exact optimal solution to this problem. The purpose of this research is to develop methods, algorithms and analytical solutions that can determine optimal placement of ground antennas to concurrently support many satellites. The resulting placement should be at least near optimal to satisfy users, contact support requirements and maximize network performance and utilization. The methods formulated will be assessed in terms of their optimality, adaptability, generality, testability, and extensibility.

PHASE I: The Phase I activity shall include: 1) the characterization of the antenna placement problem for satellite network operations based on the inputs provided, 2) the development of a set of metrics for the measurement of network performance, optimality and cost effectiveness, 3) the establishment of a set of evaluation criteria for ranking different antenna placement sets, and 4) the formulation of methods, algorithms and analytical solutions for optimal placement which will meet satellite support requirements against a given set of constraints. Details of the methods and analytical solutions shall be documented in a technical report.

PHASE II:The Phase II activity shall include: 1) the implementation of the methods/algorithms/analytical models developed in Phase I as a computer based evaluation tool, 2) construction of a representative set of test input scenarios based on AF Satellite Control Network (AFSCN) operations with assistance from SMC/CWI, 3) the execution and experimentation of the antenna placement methods driven by the test scenarios, 4) comparison between the performance and efficiency of each candidate method by assessing the cost effectiveness of the antenna placement sets generated, 5) identification of new technical issues related to the practicality of the candidate methods and additional technology needs, and 6) detailed documentation of all technical results and lessons learned from the Phase II activities.

PHASE III DUAL USE APPLICATIONS: The optimal antenna placement methods developed from this research will be applicable to a wide range of military and commercial satellite control networks that desire cost effective operations.

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4. Ertas, A. and Jones, J. C., "The Engineering Design Process," 2nd Ed., John Wiley & Sons, Inc., 1996.

KEYWORDS: optimal, antenna placement, global minimization, analytical solution, satellite network operations, network of ground based antennas

AF99-053 TITLE: Passive Instrument to Determine Propagation Effects

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop an instrument that measures propagation factors at frequencies of interest for military/commercial communication systems.

DESCRIPTION: This project concerns the military/commercial need for the design and development of a measurement system that determines the atmospheric effects on radio propagation in an earth-space path. The basic requirement is for a three frequency radiometer with appropriate data acquisition and recording capability, all suitable for field use. The instrumentation developed will be used to perform measurements at sites of interest for military and commercial users. The principal frequencies of interest are 20, 30, and 44 GHz. In recent years there has been a large effort in measuring and modeling rain attenuation and this effort is still continuing; however, some current systems operating at EHF (extremely high frequency) utilize field terminals with small apertures which consequently have small link margins. For these terminals, particularly at low elevation angles, clouds and gaseous absorption can cause a link outage. Unfortunately, cloud attenuation statistics data are not available to develop a viable global cloud model. This proposal is a step to provide the basis for characterizing attenuation in non-raining, cloudy conditions. The system is also required to be capable of measuring attenuation when it is raining. Contact with existing programs that use radiometers for measurements (such as the advanced communications technology satellite [ACTS], and National Oceanic and Atmospheric Administration [NOAA] programs) is strongly suggested prior to design/development of the instrument required for this project. It may also be advantageous to consider some coordination or collaboration with these programs. It is desirable to use commercial-off-the-shelf (COTS) hardware wherever possible to minimize cost and enhance subsequent manufacture. It is also desirable to have a single antenna to cover the frequency ranges indicated. Prior to instrument design, the approach to several key issues (among others) must be determined: 1) how the measurements should be made, 2) how data acquisition should be implemented to avoid data-taking when no attenuating medium is present, 3) how to calibrate and validate measurements, 4) what the need for ancillary data such as temperature, humidity, rain gauges, etc. is, and 5) other issues, including the requirements of dynamic range, fade dynamics, and statistics of outage.

PHASE I: 1) Develop preliminary design of radiometric instrument system, 2) with Air Force assistance, check adequacy of design parameters with other existing programs that utilize radiometric instruments to ensure compatibility of usage, and 3) develop prototype design/test plan and demonstrate mutually agreed-to key elements of the design.

PHASE II:1) Finalize radiometer design, 2) fabricate radiometric instrument system, 3) finalize test plan, and 4) complete test plan with Air Force assistance. Measurements should be performed at global ground sites of interest to military and commercial organizations in order to establish a comprehensive database on attenuation at the frequencies identified.

PHASE III DUAL USE APPLICATIONS: The military space system frequency allocations are 20 GHz for downlinks and 44 GHz for uplinks. The commercial space system allocations are 20 GHz for downlinks and 30 GHz for uplinks. Therefore, the measurement instrument to be designed for the three frequencies identified will provide dual use to DoD/commercial interests alike.

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KEYWORDS: earth-space path, global measurement, attenuation models, radio propagation, measurement system, atmospheric effects, propagation factors

AF99-054 TITLE: Generalized Guidance and Control Computer Program

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop a modern G&C software tool featuring a structured input language, a trajectory simulator, and output targeted to user-designated architectures.

DESCRIPTION: After nearly 50 years of spaceflight, custom-built computer programs are still being developed to perform the Guidance and Control (G&C) functions for individual families of aerospace vehicles. Each of these programs is concerned with performing identical functions, namely: 1) process input data from sensors and command devices, 2) determine guidance and control errors, 3) apply the appropriate steering and control laws, and 4) output commands to remain on course while maintaining a stable attitude. A pervasive need exists for a generalized, G&C software tool featuring a structured input language, a trajectory simulator, and output targeted to user designated architectures. The system should be highly modularized to allow for simulation and application to a wide variety of systems including reentry vehicles, launch vehicles, orbiting satellites and aircraft. Basic features of the system (among others) should include: 1) a problem-oriented, user-friendly input language, 2) a library of support functions commonly required for trajectory and G&C functions, 3) a system for event detection, 4) differential equation solvers that are functionally isolated from the physical models, 5) allowing targeting by simply changing the input data base, thus not requiring revalidation for every flight, and most importantly 6) the proof that the concept is viable.

PHASE I: 1) Develop an overall system architecture/design, 2) develop actual code to show feasibility of critical system components; ensure that both the development environment and the system product use the same input systems, and 3) provide a demonstration of critical system elements.

PHASE II:1) Finalize the G&C system, 2) develop an operating example of the G&C system developed from the same statement of system requirements that were used to develop (a mutually agreed-to) existing system, and 3) run a parallel comparison of the new G&C system and the selected existing system so that comparison of results can be used to demonstrate the validity of the new system.

PHASE III DUAL USE APPLICATIONS: A successful, modular, generalized G&C system would be utilized by military and commercial boosters, satellites, and reentry systems.

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KEYWORDS: targeting, space vehicle, trajectory simulator, structured input language, guidance/control functions, user-designated architecture

AF99-055 TITLE: Satellite Onboard Set Scan Processor

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Design a built-in self test processor to monitor ASICs health and provide processed test information to a redundancy controller.

DESCRIPTION: A specialized processor is needed to support built-in self tests of complex signal processing functions in DoD and commercial satellite payloads. A special purpose processor, local to a processing unit, will reduce the load on the spacecraft computer by performing low-level health and status checks, detecting anomalous operation, conducting self tests, and reporting results to the redundancy control computer which may be located either onboard or on the ground. The built-in self test processor will monitor data buses to detect parity errors, control boundary scan or signature analysis operations, and connect to digital signal processor or application-specific integrated circuits (ASIC) chips via the IEEE 1149.1 interface. The built-in self test processor receives results of checks, tests, or polling operations, and then removes redundancy and formats the data for transmission to the redundancy control computer. Innovation is required to provide flexibility and programmability so that the built-in self test processor can be configured to support a range of redundancy configurations. While conforming to standard interfaces (e.g., IEEE 1149.1), the built-in self test processor will control several types of self tests, interpret results, and format the data for either onboard or downlink transmission. The test procedures and data formatting shall be programmable to facilitate interfacing with different user architectures and designs. Government input as to specific processor requirements shall be provided.

PHASE I: Develop an architecture for the processor which will implement test and monitoring functions while providing flexibility and programmability. The processor architecture shall include a means for fault detection and a means for either bypassing the processor or providing fault recovery. The results shall be documented in a report and a plan for a prototype development in Phase II shall be included. Mutually agreed-to key elements of the processor shall be simulated/demonstrated.

PHASE II:Develop a working prototype of the built-in self test computer. The processor shall interface with real and emulated ASICs to demonstrate the recognition of anomalies and the processing associated with error reporting and redundancy removal. The prototype processor shall demonstrate how it operates with a simulated payload redundancy management system. A plan for radiation hardening and flight qualification shall be provided, as shall estimates of the size, weight, and power.

PHASE III DUAL USE APPLICATIONS: The built-in self test processor should be useful for either military or commercial satellites. New commercial satellite designs for personal communications and high speed Internet access employ constellations with a large number of satellites. These applications can benefit directly from a space qualified built-in self test processor regardless of whether the built-in self test processor is used onboard or only in the spacecraft integration and test. The built-in self test processor will be a useful element in any commercial system employing ASICs and requiring either a robust design or full fault tolerance. Commercial aircraft and telephone switching are two examples where fault tolerant processing or computing is required. The built-in self test processor may also be useful in reducing costs of testing for any sophisticated electronic system.

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KEYWORDS: parity errors, fault tolerance, data compression, built-in self test, signature analysis, redundancy control,set scan processing, satellite communications

AF99-058 TITLE: Automatic Test Pattern Generation (ATPG) Tool Development

TECHNOLOGY AREA: Modeling and Simulation (M&S)

OBJECTIVE: Identify causes for errors and discrepancies between industry standard ATPG tools, compare results with deterministic tools, and develop an accurate ATPG.

DESCRIPTION: Critical processing applications such as banking, medical electronics and space electronics require a high degree of confidence that the electronic components are operating within specification. In particular, validating the performance of Application Specific Integrated Circuits (ASICs) at the device level both reduces the cost and schedule impacts of subsystem and system integration and minimizes the possibility of outage from anomalous circuit behavior during the operating lifetime of the ASIC. ATPG tools provide screening vectors to thoroughly test ASICs. There currently is no way to verify the accuracy of ATPG-based tests. In the absence of verifiable accuracy, ATPG manufacturer fault coverage claims cannot be substantiated.

PHASE I: 1) In cooperation with the Air Force, assess the relative accuracy of the most commonly used industry standard ATPG tools based upon measurement of a large variety of representative ASIC circuits. 2) Establish the absolute ATPG accuracy for each representative circuit by comparing the ATPG benchmark results to those obtained by the use of deterministic fault grading tools (those that do not make assumptions or use ATPG algorithms) on the identical representative circuits. 3) Based upon comparison of results, develop the architecture/specification for an improved accuracy ATPG tool. 4) Demonstrate key elements of the improved ATPG tool to provide confidence in the integrity of the concept.

PHASE II:1) Develop a fully functional prototype of the improved accuracy ATPG tool. 2) Apply the improved accuracy ATPG tool and selected deterministic fault grading tools to the measurement of a common set of ASIC circuits and compare the results. 3) Modify the improved accuracy ATPG, if required, and repeat the comparison process until the improved accuracy ATPG tool meets specification.

PHASE III DUAL USE APPLICATIONS: Applications Specific Integrated Circuits (ASICs) are used extensively in commercial and military satellites. As ASICs gate counts increase, the fault coverage accuracy of ATPG tools will become increasingly important in order to assure testing quality/integrity. In particular, it is crucial that ASICs be completely and accurately tested in order to mitigate the risk of a faulty chip ending up on a satellite space system or in thousands of personal computers which would result in costly schedule setbacks, troubleshooting, and repairs.

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KEYWORDS: ASIC circuits, screening vectors, verifiable accuracy, anomalous circuit behavior, deterministic fault grading tools, automatic test pattern generation

AF99-059 TITLE: Transportable Standard IR Calibration Source

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop a transportable standard IR calibration source.

DESCRIPTION: DoD, NASA and commercial satellites are using more and more of the IR spectrum for object surveillance, detection discrimination, and identification. These systems are utilizing state-of-the-art sensors with constantly improving detectivities. Older radiometric test chambers are being upgraded, and new ones are being constructed to test and calibrate these new sensors. However, spectroradiometric IR calibration sources have not kept pace with IR chamber testing and calibration requirements for these sensors working at detectivities below 10(-10) watts/square cm/sr/micron. The objective of this project is the development of a transportable standard (radiometric) IR calibration source (covering the spectroradiometric range of 0.5-15 microns). If met, this objective will fill a void in current calibration and testing capabilities for such sensitive detectors, and will allow military surveillance and MASINT (management of measurement and signature intelligence) users, Government/Academic research and the Commercial earth resources communities, to take advantage of sensor performance improvements, resulting from significantly improved IR ground calibration resources. The result will be that users will be able to extract far more useful information from data collected from the IR sensors. The design requirements for the subject standard IR calibration source (among others) include: 1) that it be an easily transportable, point and constant flux diffuse source calibration instrument(s), covering the spectroradiometric range of 0.5-15 microns, and 2) that it be generically compatible with a wide variety of radiometric test chambers. The issue of compatibility with (modernized) existing and new radiometric test chambers should be based upon a thorough facilities/capability analysis of DoD/Academic/Commercial radiometric test chamber resources.

PHASE I: 1) Collect background information/data on existing and new radiometric test chambers; 2) integrate the data collected and develop specifications/preliminary design for a transportable point and constant flux diffuse source (or family of sources) radiometric calibration instrument, covering the 0.5-15 micron range; and 3) demonstrate (mutually agreed-upon) key elements of the design to provide confidence in a successful Phase II project.

PHASE II:1) Complete the design, engineering development, fabrication, functional testing and calibration to known standards for the transportable spectroradiometric instrumentation, and 2) provide a fully functional demonstration to Air Force specifications.

PHASE III DUAL USE APPLICATIONS: Successful development of the transportable spectroradiometric calibration instrumentation will avail a resource to DoD/NASA/Commercial satellites which will result in significantly improved (object surveillance, detection discrimination, and identification) IR sensor performance.

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KEYWORDS: sensors, infrared spectrum, radiometric source, object surveillance, detection discrimination, radiometric test chamber, spectroradiometric IR calibration

AF99-060 TITLE: Emerging Technologies in Training Development

TECHNOLOGY AREA: Manpower, Personnel, and Training

OBJECTIVE: Develop less labor-intensive methods of instructional development.

DESCRIPTION: The current trend in satellite control (as is the trend in many military and commercial areas) is to move from highly trained and highly educated satellite operators to a small cadre of lower skilled operators with engineering support (front room/back

room concept). This trend also impacts mission analysts, spacecraft designers, and warfighting commands assessing space-based concept of operations and applications of future space technologies. One of the challenges of this method of operation is to provide adequate, effective, low cost, comprehensive training and education for these lower skilled operators and those developers/planners/users new to the space community. Automated training has the potential to provide effective, low cost training/education. However, developing automated training/education using current technology is a highly labor-intensive process, requiring 200-600 hours of construction time for every hour of instruction. A need exists to develop an innovative, highly cost effective automated training development technology which will avail automated training instruction methodology to a broad range of military and commercial training requirements. In relation to the Air Force requirement for satellite operators, the following issues (among others) should be addressed: 1) cost efficient use of artificial intelligence (AI) in training, 2) task analysis of satellite operation, 3) portability and interoperability of training systems with operational requirements, 4) maintenance/support of training systems, and 5) use of modeling and simulation to support training/educational requirements for individuals new to the space community in positions from research and development, to satellite operators, to command staff levels.

PHASE I: 1) Develop an architecture for a generalized method of efficient development of automated instruction, and 2) develop a prototype system and demonstrate mutually agreed-to key elements of the system.

PHASE II:1) Refine and finalize the methodology for development of automated instruction, 2) develop an automated training instruction vehicle (with Air Force cooperation and input) for training satellite operators, 3) test the effectiveness of the training system (with Air Force assistance) on actual satellite operators, and 4) transition the system to another satellite family and demonstrate the generality of the design.

PHASE III DUAL USE APPLICATIONS: The technology developed under this program will have a high commercialization potential, applicable to virtually any training environment in the government or civilian sector. One of the biggest barriers to widespread use of automated training is the prohibitive cost. Development of new techniques for creating this training should serve to greatly increase the sphere of environments over which automated training can be utilized. Both military and commercial satellite operators will benefit from this technology.

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KEYWORDS: satellite control, automated training, satellite operators, intelligent systems, artificial intelligence, instruction methodology

AF99-061 TITLE: Advanced Cryocooler Technology

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop and demonstrate cryocooler technology for next generation spacecraft cooling applications.

DESCRIPTION: Next generation space infrared sensing technologies and spacecraft cryocooling needs will require revolutionary improvements in cryocooling technology. Exploitation of technology with minimal or no moving parts, minimal mass, minimal input power, minimal vibration, high efficiency, and high reliability are essential to meet cryocooling goals for shrinking Air Force (AF) and Department of Defense (DoD) infrared sensing payloads. Specific interests include, but are not limited to, advanced thermoelectric coolers, low temperature (near and below 10 K) regenerators, laser or fluorescent cooling, cooling across a gimbaled joint, and continuous sorption cooling. In addition to these needs, producibility, reliability, and manufacturability are important to AF and DoD applications.

PHASE I: Demonstrate the adaptation of an innovative technology in a breadboard format. This can include demonstration of a fundamental physical principle in a format that illustrates how this technology can be utilized in a cryocooler. This effort should include plans to further develop and exploit this technology in Phase II.

PHASE II:Develop an engineering design model device or cooler. This device may not be optimized to flight levels, but should be able to demonstrate the ability of the contractor to create a working device. Demonstrate the potential improvements in mass, input power, efficiency, and/or reliability. The contractor should keep in mind the goal of commercialization of this

innovation.

PHASE III DUAL USE APPLICATIONS: Applications of this technology potentially could be far reaching. Typical AF and DoD military space applications relate to infrared sensing, cryogen management, electronics cooling, and superconductivity. Specific examples include the track sensor (~0.5 W @ 35K and 60K), and gimbaled optics (~6-10 W @ 100K) cooling for the SBIRS Low EDM system. Another key area of interest is in the (0.1-2 W @ 4-10K) range in support of military, NASA, civil, and commercial users. These user applications include missile tracking, surveillance, astronomy, mapping, weather monitoring, and earth resource monitoring. However, the need for high reliability cryocoolers for terrestrial applications includes cellular bay station cooling and magnetic resonance imaging. If the developed innovation is low cost, potential applications include CMOS cooling of workstations and personal computers.

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KEYWORDS: space, cooling, cryogenics, cryocooler, infrared sensors, thermal management, cryogenic refrigerator

AF99-062 TITLE: Space Vehicles Technology Development

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop innovative methods for improving the performance, endurance and survivability of future space and missile systems.

DESCRIPTION: Future space systems require a variety of integrated technology developments in order to meet improved performance requirements. We are seeking innovative approaches and technology developments which will provide effective and affordable future space vehicles, launch vehicles and space concepts with improved space system performance, endurance and survivability. Proposed approaches shall emphasize dual use applications, i.e., those which clearly offer private sector as well as military applications. Proposals emphasizing technology transfer will receive additional consideration. Areas of interest include:
Surveillance and Control Technologies: Advanced technologies which revolutionize space-based surveillance and space operations. This includes technologies in infrared focal planes, cryocoolers, hyperspectral imaging, satellite control/autonomy, satellite guidance and navigation, astrodynamics, radiation hardened electronics, space debris analysis, threat warning and attack reporting, and modeling and simulation.
Space Technology Integration and Demonstration: Innovative approaches for the development, integration and demonstration of emerging vehicle technologies and space concepts in the areas of thermal management, space power/energy storage, and space structures and controls.
Battlespace Environment: Technologies enabling the detection and understanding of threats in the aerospace environment to space systems across the full range of natural and man-made sources as well as passive and active means to eliminate or mitigate those threats. Specific areas include solar activity effects, ionospheric impacts, space hazard mitigation, radiation environment characterization, atmospheric modeling, space background characterization, and space weather impact decision aids.

PHASE I: Develop concepts and perform analyses to establish the feasibility of the proposed approach.

PHASE II:Complete the Phase I design and develop a demonstrator or prototype. Document the research and development and develop a technology transition and/or insertion plan for future systems and commercial ventures.

PHASE III DUAL USE APPLICATIONS: Space systems for DoD and commercial use require advanced technologies that are highly reliable, high performance, and survivable to a wide variety of man-made and natural environments. These technologies have immediate and definite commercialization potential in consumer goods and infrastructure improvements.

REFERENCES: Bednarz, Eugene, "Space Vehicles Technologies," Point Paper, Apr 98; web site addres: TBD.

KEYWORDS: atmospheric modeling, hyperspectral imaging, space-based surveillance, pace-power/energy storage, satellite control/autonomy, satellite navigation/control, rad-hard/tolerant electronics, space structures and controls, radiation environment mitigation, space-background characterization

AF99-063 TITLE: Self-Consuming Satellite

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop/evaluate satellite architectures that save weight by using the satellite structure as a propellant.

DESCRIPTION: The traditional approach in designing satellites is to structurally stiffen the satellite so that it will survive during the launch environments; once on-orbit, the satellite structure mass is no longer needed. This approach is a very inefficient way to design satellites, considering the fact that a kg of mass costs tens of thousands of dollars to put into space. Therefore, it is necessary to devise different ways to structurally stiffen the satellite so that the stiffening elements can be used for other purposes. One such concept is to have the satellite propellant be a part of the satellite. Therefore, this program shall develop a new satellite architecture that will incorporate the satellite's propellant in the satellite structure. Weight and volume reductions in the satellite will be accomplished by using the propulsion system's propellant as part of the load-bearing structure of the satellite.

PHASE I: Define the most promising propulsion concepts that can be used as load bearing structures. Perform a preliminary structural analysis on the most promising concepts to determine the feasibility of a self-consuming satellite. This will include incorporating propulsion requirements such as delta-V requirements, the number of thrusters, etc., as well as structural requirements such as weight, launch loads and stiffness.

PHASE II:Demonstrate concepts defined during Phase I with a prototype satellite structure. A detailed structural analysis will be performed on the most promising concepts, and a demonstration article shall be built and tested to verify results of the detailed analysis. Performance testing shall include subjecting the demonstration article to actual launch conditions.

PHASE III DUAL USE APPLICATIONS: Reduction of satellite weight is an important consideration for both military and commercial space industry. Therefore, there is a large market for a self-consuming satellite that makes use of the existing satellite load-bearing structure.

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KEYWORDS: MEMS, cannibalization, micropropulsion, digital propulsion, structural stiffening, self-consuming structures

AF99-064 TITLE: MEMS Integration for Micro-Spacecraft

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop micro-machining, MEMS, and meso-scale electro-mechanical approaches for advanced microspacecraft applications in these fields.

DESCRIPTION: New advances in the fields of micro-machining, MEMS, and meso-scale electro-mechanical approaches, when combined, are expected to provide enabling benefits in the capability of space systems. Space systems need improved power and thermal management, propulsion, sensor integration, and embedded electronically-activated actuator assemblies. Micromachining technologies, especially those pertaining to silicon, have evolved over the last several decades. They suggest the possibility of extraordinary efficiencies in their functional domain as compared to their "macro-machined" analogs, alleviating bulk in the replaced component and reducing next-level structural interfaces, cooling/heating requirements, etc. While promising developments have been reported, many micromachining concepts remain lab curios.

Finding MEMS applications for spacecraft may be even more challenging. Few of the novel concepts have been shown useful to spacecraft--gyros do not have enough accuracy, actuators do not have a useful role, etc. We believe the categories for MEMS-based improvements include: improved thermal management, micro-encapsulated cryogenic coolers (for infrared focal plane arrays and detectors), positive component securing techniques, embedded multistable relays, micro-connectors, micro-propulsion, micro-optical systems, active control, etc. Practical technology insertion must be addressed, particularly noting the space environmental context of prospective applications. Also a chief issue is the efficient packaging of MEMS devices and co-integration with electronics. More than enabling size, weight, and power reduction, MEMS can also promote the significant issues of ease of integration through novel concepts that allow rapid and standard access and interchange of spacecraft panels, intra-panel components, and internal spacecraft bus systems.

PHASE I: Design and develop novel micro- and meso-scale electromechanical concepts. Address practical techniques to improve particular aspects of spacecraft systems. Many MEMS "toys" exist, and it is not the intent of this effort to build variations on "well-tread" themes. The ability of a Phase I concept to make an enabling difference to spacecraft bus or relevant payload size, weight, power consumption, or ease of integration is desired. Identify actual devices, and if possible, produce preliminary prototypes.

PHASE II:Demonstrate the repeatable, quality formation of components. Ties to spacecraft demonstrations are particularly important. We highly encourage cooperation and leveraging of existing technologies. Any third-party industrial or government offers of leverage in the Phase II effort and post-Phase II endeavors would be desirable. The results of a successful Phase II approach would lead to superior micro- and/or meso- devices and applications of those devices that could be inserted in certain space-based systems.

PHASE III DUAL USE APPLICATIONS: MEMS technologies are assessed as having multi-billion dollar market potential. Any breakthrough application in this SBIR will further enhance the utility of MEMS devices in terrestrial and commercial space.

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KEYWORDS: network, crosslink, lightweight, high data rate, data transmission, miniature hardware, space communications

AF99-065 TITLE: Thermal Management for Advanced Packaging in Payload Electronics

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop innovative thermal management technologies for future large, wafer scale, space-based integrated circuits.

DESCRIPTION: Future space-based electronics systems will require innovative packaging solutions to enable space systems to meet size, weight, power, and lifetime reliability requirements. Commonly, these approaches are based on efficient 2-D and 3-D arrangements of electronics, often involving "multi-chip-modules" (MCMs). As chips are packaged closer together, the area/volume power density (heat flux) increases. It is conceivable that future packaging densities will be such that the resulting heat generated during operation cannot be removed fast enough with conventional heat-sinking schemes to sustain an equilibrium below critical operating temperatures. Innovative solutions are sought for modular heat removal from one or two faces (approximately 5cm x 10cm area for each face) of a 3-D stack of MCM substrates. Solutions must meet the following additional requirements: 1) it must allow for easy removal and replacement of the MCM stacks, 2) it must have a minimum conductance across the interface of 100 Watts/C-cm2, 3) it must operate in a space environment for a minimum of 10 years, and 4) it must transport a minimum heat flux of 20W/cm2. Examples of possible solutions include but are not limited to: pumped fluid loops, heat pipes, capillary pumped loops, looped heat pipes, and highly conductive epoxies/fillers. Although technology dependant assumptions may impact a solution (e.g. all-CMOS), emphasis should be placed upon innovative mechanisms that result in the removal of the required amount of heat.

PHASE I: Evaluate/develop conceptual designs for techniques that can provide significant thermal management improvements compared to the thermal management techniques used in conventional packaging approaches. Conduct proof-of-concept demonstrations to indicate the practicality of such techniques for use in military and space systems.

PHASE II:Construct a functional system which demonstrates the ability to remove high amounts of heat (the exact amounts will be established based primarily on Phase I analyses). The demonstrated system must be capable of operation under severe thermal, mechanical, and radiation environments. Furthermore, the constructed systems must demonstrate the feasibility of heat removal by simulating the electrical power loading of "typical" electronic systems and then demonstrate thermal equilibrium of this

system in operation.

PHASE III DUAL USE APPLICATIONS: The thermal management techniques will find commercial application in projects of interest to government, industry, and academia, especially with respect to commercial space applications. The unique thermal boundary conditions of the space environment do not permit solutions widely used in terrestrial applications such as air-cooling. It is also possible in certain circumstances to find applications in other domains where large amounts of dense circuitry can be confined with limited airflow boundary conditions.

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KEYWORDS: heat pipes, multi-chip module, pumped fluid loops, thermal management, high flux heat transfer, conductive epoxies/fillers, high density electronics cooling

AF99-066 TITLE: Autonomous Control of Multiple Satellites Using Intelligent Software Agents

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Design and develop a multi-agent supported architecture which would be used to autonomously monitor and control multiple satellites.

DESCRIPTION: At the present time there is very little automation onboard Air Force satellites as relates to surveillance payload missions. Large amounts of data are collected from each satellite and downlinked to the ground where a variety of independent techniques are used to assess whether there exists any information of value. In addition, there is virtually no collaboration between satellites with respect to each others' position or knowledge about detected objects of interest. The amount of data collected and downlinked could be significantly reduced if more intelligence is placed onboard, providing the ability to process, detect, and interpret information onboard the satellite and adjust and/or configure sensors accordingly based on sensor data. A large number of past and current research efforts have focused on target recognition under a variety of different environments and scenarios. The focus of this research topic is to leverage off of that research and to develop a top-level onboard executive controller which would monitor and control the processing of satellite data and sensors. Each satellite's onboard controller would operate autonomously in cooperation with executive controllers onboard other satellites as well as ground-based controllers. Each of these controllers would act as top-level intelligent agents. The basic concept behind an intelligent agent is the notion of an independent software entity that operates within some environment (e.g., satellite sensing environment) while always attempting to achieve some goal (e.g., detecting entities, controlling sensor pointing, etc). Agents can have a simple task such as monitoring a battery voltage, or they can have a much more complex function such as detecting specific targets using technologies such as neural networks. The way each agent reacts and attempts to achieve its individual objective is based on stimuli received from other entities within the environment. Each of these top-level agent-based controllers would in turn communicate with lower-level agents which would have more specific tasks. The strength of the agent approach to satellite autonomy is the ability to react to uncertainty and changing mission requirements. A key to this research effort is the ability of the agents to cooperate with one another whether they reside on the same satellite or across different satellites. For example, an agent residing on one satellite may detect some object of interest and react accordingly. To optimize information processing, relevant information can be made available to a second satellite such that when the object comes within its field of view it can already be configured to optimize observation of the object in question. The notion of an intelligent agent-based controller can be extended to include health and status related satellite autonomy.

PHASE I: Develop a detailed design and description for this agent-based architecture for satellite payload autonomy. This will include, but not be limited to, the following: 1) mechanism by which agents communicate, 2) means by which a situational assessment is made based on the status of individual agents, 3) detailed description of the satellite surveillance domain and where and how various agents would be utilized, and 4) specification of the software and hardware platform to be used along with a description of the key software agents to be used. Of the above goals, inter-agent cooperation is considered most important. A prototype demonstration of the proposed architecture is desired.

PHASE II:Implement the design generated in Phase I and provide an in-depth demonstration of its capability. The architecture should be designed such that it can be extended easily to incorporate new agents as needs arise. Demonstration of this extensibility/flexibility is desired. Demonstrating this technology in an actual flight experiment is ideal; however, if time and cost prevent this, then the demonstration should be as realistic as possible with an easy migration towards a flight experiment.

PHASE III DUAL USE APPLICATION: Satellite autonomy is a critical concern in both military and commercial space industries to increase reliability while reducing operating costs. The concept of an intelligent agent architecture is not specific to satellite autonomy, but has applicability to any number of different domains. Any process which involves monitoring a number of different entities from different sources and providing a situational assessment based on all of these entities could benefit from such an intelligent agent-based architecture.

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KEYWORDS: autonomous agents, intelligent agents, executive controller, agent communications, situation assessment, smart optical sensing, intelligent satellite control

AF99-067 TITLE: Advanced Diagnostic and Modeling Techniques for the Ionosphere and Upper Atmosphere

TECHNOLOGY AREA: Battlespace Environments

OBJECTIVE: Develop techniques for the characterization and environmental monitoring of ionosphere, and assessing radio-frequency propagation effects through ionosphere.

DESCRIPTION: Advanced diagnostic techniques for characterizing the earth's atmosphere above 50 kilometers are required for better determination of atmospheric effects on radio-wave propagation for civilian and military space-based communication, navigation, and surveillance systems. Therefore, advanced diagnostic and modeling techniques for the characterization of the ionosphere and upper atmosphere, as well as environmental monitoring of the ionosphere and upper atmosphere, are needed. Physical quantities of interest include neutral compositions, ion compositions, densities, temperatures, winds, collision frequencies, recombination rates, diffusion rates, scintillation parameters, and electric fields. Appropriate responses may include diagnostic techniques for ground-based remote measurements. Because the ground-based systems may be deployed to various world-wide locations that are often primitive and remote, the system should be easy to operate, maintain, and transport. The ability for the system to facilitate telescience research is highly desired. Responses may also include advanced modeling or numerical techniques that facilitate or augment ionosphere and upper atmosphere diagnostics. In addition to the natural atmosphere, consideration should be given to the diagnosis of atmospheric regions that are modified by powerful high frequency transmissions produced by facilities such as the High Frequency Auroral Research Program (HAARP); diagnostics specifically designed to work in conjunction with these transmitters are acceptable. Proposed diagnostics should assess the dual use commercialization potential and exploit commercial off-the-shelf components whenever possible. Responses may include proposals for instruments based on completely new diagnostic principles, improvements of known diagnostic techniques by exploiting recently available technology, or the development of new analysis techniques or human interface systems that substantially improve the information yield from existing diagnostics.

PHASE I:Develop a diagnostic concept that provides an improved hardware or measurement capability. Produce a detailed design for an experimental instrument or algorithm based on that concept. Delivery of prototype is encouraged.

PHASE II:Based on the Phase I design work: 1) construct or further develop experimental instrument(s) or algorithm(s), and 2) demonstrate the instrumentation or algorithm. Delivery shall include documentation on the operation and maintenance of all delivered hardware and/or software.

PHASE III DUAL USE APPLICATIONS: Industries interested in this work include telecommunications, aviation, and civil Global Positioning System (GPS) manufacturers. SBIR results will be applied to these industries by providing technologies that make space-based communications and space-based navigation more secure and reliable. Anticipated benefits include improved satellite phone reception such as with Iridium or Inmarsat phones, and forecasts of poor GPS satellite reception to commercial airliners which will eventually rely on this technology for landing operations. Within the government, new and improved atmospheric diagnostics have concrete applications for nuclear ban treaty verification and theater missile defense strategies. Diagnosis of the mesosphere is also becoming increasingly important as a means of environmental monitoring for both the military and civilian sectors; such instruments can be effectively applied to expanding initiatives on global change in both the U.S. and abroad. As has happened in the past, new designs for diagnostics of the ionized upper atmosphere may be readily adapted by the plasma fusion community (e.g., incoherent scatter, Langmuir probes, radio-frequency sounding) to investigate laboratory-scale plasma environments.

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KEYWORDS: ionosphere, telescience, environmental monitoring, ionospheric scintillation, radio-frequency propagation

AF99-068 TITLE: Power Distribution Architectures for Miniature Spacecraft

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop smart power architectures with high efficiency, robustness, and flexibility for miniature and micro-satellite applications.

DESCRIPTION: Improved power distribution and management architectures are needed in small satellites. These systems need robustness to deal with space radiation and thermal environments. High efficiency is also needed, as power in space systems is a precious commodity. Efficiency is a great concern in low-voltage designs, due to loss of headroom in the power conversion electronics and the increased impact on switching and rectification losses. Finally, smart power systems with improved flexibility are needed. Presently, every change in input voltage range, output voltage range, or load conditions promotes a new convertor design. New solutions are needed to create smarter power convertors, allowing one or a small family of convertors to support a wider range of requirements. Standardized distribution manifolds for power as integrated in a structural panel is another intriguing possibility, if it can be shown to be sufficiently flexible for a wide range of satellite bus and payload applications.

PHASE I: Define particular promising concepts and conduct bench-top demonstrations, electrical simulations, and/or other types of demonstrations, with a convincing plan for integration of these concepts into a suitable form for Phase II.

PHASE II:Demonstrate power concepts in a flight-like configuration, possibly in a manner suitable for direct use in space experiments.

PHASE III DUAL USE APPLICATIONS: Power management and distribution approaches are central to complex electronics platforms. While residential power distribution concepts have been in existence for nearly a century, and some power standards exist in automobile and aircraft platforms, the point-of-load end of the power chain is in many cases fairly rudimentary. Smart power and improved standard distribution manifolds and architectures would greatly improve certain platform concepts in the commercial as well as military world, including ship, automobile, and aircraft.

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KEYWORDS: power electronics, dc-dc power conversions, late-point configuration, point-of-load conversions, distributed power architectures, power management and distribution

AF99-069 TITLE: Innovative Measurement Techniques for Space-Based Remote Sensing/Standoff Detection

TECHNOLOGY AREA: Battlespace Environments

OBJECTIVE: Develop optical techniques for optimizing target-to-background contrast and identification/ quantification of materials and atmospheric constituents/effluents.

DESCRIPTION: The Air Force Research Laboratory's Battlespace Environment Division (AFRL/VSB) is interested in innovative techniques and approaches which leverage recent progress in commercial technology to characterize the optical properties of the environment, to optimize target detection, search, and track capabilities in structured environments, to identify materials, and to identify and quantify atmospheric constituents/effluents. Examples include passive optical techniques which collect spectral, spatial and temporal data. Many commercial technologies are emerging that could be developed into innovative measurement technologies. The focus of the efforts will be directed toward space-based applications.

PHASE I: Conduct analyses comparing candidate data collection and analysis approaches to current technologies with

respect to sensitivity, spectral and/or spatial resolution, temporal resolution, etc. New data collection and data processing methodologies will be defined and assessed in terms of target-to-background contrast enhancement and/or clutter suppression, as well as for accuracy and speed. Explore techniques to identify materials and to identify and quantify atmospheric constituents/effluents. Investigate ways in which new technologies could be applied to other military and commercial applications.

PHASE II:Conduct tests to determine how effectively the proposed techniques address the requirements of the intended application(s). Develop an automated, near-real-time, data processing system, and demonstrate this system using synthetic and real data.

PHASE III DUAL-USE APPLICATIONS: The techniques and methodologies developed under this effort potentially will be useful in military systems requiring autonomous threat recognition and identification under stressing conditions of cloud and haze cover, sensor clutter induced by scene structure, as well as for the identification of materials, and the identification and quantification of atmospheric constituents/effluents. Potentially it will be useful also for non-military applications involving target/species recognition under stressing real-world conditions of scene-induced clutter/noise and spectral interference.

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KEYWORDS: data analysis, hyperspectral, ultraspectral, multispectral, remote imaging, remote sensing, data processing, data acquisition, target detection, spectral signatures

AF99-070 TITLE: Thin Film Flexible, Li-Based Batteries for Space

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Demonstrate feasibility of thin-film, flexible, lithium batteries with sufficient cycle life, capacity, and low temperature operation for LEO space applications.

DESCRIPTION: In space batteries, there is a significant push toward designing and producing lighter, more robust, higher energy density batteries. One trend in satellite design is toward constellations of low power, lightweight, collaborating smallsats that work together to perform a specific mission. For smallsat applications, the energy storage subsystem must be very light and capable of minimizing its mass while meeting the power needs of the spacecraft. One way of addressing these needs is by examining the feasibility of thin film, flexible, lithium batteries with either solid or gelled electrolytes. Due to reduced liquid, both types of electrolytes have distinct mass advantages over cells with conventional liquid electrolytes. Even for gelled polymers, which contain some liquid, the amount of liquid electrolyte is greatly reduced. The Air Force is interested in thin film, flexible, Li-based batteries that could be employed in a wide variety of configurations such as large arrays and/or cylinders, or could be conformed to the shape of and attached directly to spacecraft components. At the battery level, developed concepts should be at least 100 W-hr/kg and be capable of operating at less than 25 degrees C for 5000 cycles.

PHASE I: Investigate potential chemistries for thin film, flexible cells. Demonstrate feasibility of several concepts with small area cells and a small number of cycles.

PHASE II:Initial optimization of chemistries identified in Phase I. Downselect to most promising concept and perform detailed optimization. Place several cells in several configurations on life cycle test with LEO mission profile. Identify industry partners interested in producing and commercializing final product.

PHASE III DUAL USE APPLICATIONS: A large market exists for thin film battery technology both in space and terrestrially. Many LEO communications satellite systems are currently being flown, and a lightweight, large capacity, thin film battery would be very useful for increasing the capability of these satellites for military and commercial applications. Terrestrially, these batteries could enable next generation laptop computers and other electronic components, which is a large, sustainable market.

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KEYWORDS: thin film, space power, lithium ion, energy storage, secondary battery, polymer electrolyte

AF99-071 TITLE: Latching Microrelays in Thin Plastic Material Systems

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop latching microrelays and microswitches that are compatible with Multi-Functional Structure (MFS) substrate materials.

DESCRIPTION: The global need is to develop a latching switch that can be fabricated directly in high density packaging materials. The Air Force problem is to decrease the mass and volume of switches used in space systems, and to make these switches compatible with proposed microsatellite system bus architectures, specifically the Multi-Functional Structure system (MFS) in which interconnect wiring is formed directly in a laminated plastic substrate which also functions as the spacecraft structure. Latching relays fabricated directly in the MFS substrate will increase the flexibility of microsatellite design. Beyond the usual power routing and overload protection tasks, this embedded switching capability will make it possible for the system to reconfigure itself when hardware fails, or to switch in backup systems. Numerous high fidelity DC-capable switches will make the multifunctional substrate more flexible at the design stage by allowing a more generic architecture to be manufactured in volume, then customized for the specific hardware mounted on it by setting the switches properly. This re-routing capability will also enable on-orbit robotic repair of electrical systems, or will add new modules to an existing system. Acceptable approaches would employ some form of actuator change the state of the switch, which does not require power after state change. To meet Air Force needs, each switch should consume no more than 100 mW of power for no more than 500 milliseconds when changing states, and must be completely unpowered when in the final state. Each individual switch should be capable of carrying 1 ampere at 5 volts, and should have a standoff voltage TBD above 3,000V when the contacts are open. Switches should employ industry standard metalization for reliable contacts. Switches should fit within an area of approximately 2 x 0.25 cm. The switch must have at least 2 stable positions, and the design should be flexible enough to allow a single actuator to throw multiple contacts, i.e. a multi-pole, double-throw switch. Switches must be fabricated directly in the MFS material system, the main component of which is the laminated Kapton plastic sheets. Actuators must operate in the natural space environment within a TBD temperature range. Contact resistance for a single closed contact should not exceed 0.1 ohms. The actuation circuitry must be isolated from the signal path being switched.

PHASE I:Establish the viability of the actuation mechanism, and develop the fabrication techniques for the actuator(s). Outline the possible latching switch architectures. Concept demonstration can consist of an final-sized actuator moving a mockup switch between the two stable states, with or without final metalization. Establish a clear path for full fabrication.

PHASE II:Finalize development of Phase I switch design, with a clear path toward making the device manufacturable in large quantities. Concept demonstration will be an array of 32 switches making reliable low resistance (less than 0.1 ohm) connections for each of 100,000,000 cycles.

PHASE III DUAL USE APPLICATIONS: The military, as well as commercial space industry, will benefit from this technology which reduces mass and volume of switches in space systems while increasing flexibility. These switches will be compatible with overlay-style high density electronic packaging, and as such will find a market in the mobile communications area as well as portable electronic test hardware.

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KEYWORDS: MEMS, Kapton, electronics, mesomachines, latching microrelay, contact metalization

AF99-072 TITLE: Integrated Power Cell

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop a thin, flexible, lightweight integrated satellite electric power system using thin film solar cell, thin film battery, and lightweight power electronics technologies.

DESCRIPTION: The combination of thin-film solar cells, thin-film batteries, and miniaturized control electronics into an integrated system is called the integrated power cell (IPC). This combination of power subsystems provides a cost effective and highly modular power system. IPCs interconnect with one another to provide a complete power system with minimal exterior design and configuration. The development of this technology will build on recent progress made toward development of thin film batteries, thin film solar cells, and miniaturized power electronics. One challenging aspect of the IPC will be the integration of the battery with the other components, where the battery is typically intolerant to wide temperature variations. The final result is a very high specific energy density (>15 W/kg) and reduced $/W standard electric power system product that can be ordered with a variety of solar cells, batteries, and electronics.

PHASE I: Design suitable technical approaches needed to enable integration of thin-film solar cell, battery, and electronics functions. Identify a suitable flexible substrate, flexible microbattery device, low temperature thin-film solar cell, and power management and control electronics architectures.

PHASE II:Phase II will focus on scaleup issues which include the flexible IPC product configuration, sizing of the final IPC array, and first-order cost modeling.

PHASE III DUAL USE APPLICATIONS: Dual-use commercial potential is excellent for small and medium-sized commercial satellites, where the goal for the IPC of >15 W/kg is a factor of 3X greater than current commercial SOTA systems.

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KEYWORDS: solar cells, pace power, power storage, energy storage, integrated power, power management, energy generation

AF99-073 TITLE: Advanced Algorithms for Exploitation of Space-Based Imagery

TECHNOLOGY AREA: Battlespace Environments

OBJECTIVE: Develop algorithms to optimize detection, identification and tracking of targets for materials identification and for identification/quantification of atmospheric constituents/effluents.

DESCRIPTION: The Air Force Research Laboratory's Background Clutter Mitigation Branch (AFRL/VSBM) is interested in innovative techniques for the mitigation of clutter effects in an effective and computationally efficient manner for optimum search, detection, and tracking performance of space-based optical (ultraviolet/visible/infrared) systems. Mitigation requires advanced algorithms based upon spatial, temporal, and spectral techniques. Data from space-based missions has led to a data base of optical data (ultraviolet, visible, and infrared) to characterize the optical properties of the environment which could be exploited to explore potential space-based detection techniques for clutter-mitigation/contrast-enhancement techniques to optimize target detection, to identify materials and to identify and quantify atmospheric constituents/effluents. While many (individual) techniques exist, many have not been properly evaluated for optimum utility at the systems level, nor have they been systematically combined to assess the potential benefits of concatenating algorithms to improve detection probabilities/reduce false-alarm rates.

PHASE I: Conduct analyses, using real data, to identify the classes of algorithms for clutter-mitigation/contrast-enhancement techniques to: 1) optimize target detection, search, and track capabilities in structured environments, 2) identify materials, and 3) identify and quantify atmospheric constituents/effluents. Compare and contrast the candidate algorithms. Provide a suite of preliminary algorithms suitable for testing with experimental and simulated data.

PHASE II:Perform detailed analyses and demonstrate the efficacy of algorithms for: 1) target detection, search, and track in structured environments, 2) materials identification, and 3) identification and quantification of atmospheric constituents/effluents. Conduct tests, as required, to assess the effectiveness of the algorithms. Develop and demonstrate an automated, near-real-time

processing system using real-world data sets.

PHASE III DUAL-USE APPLICATIONS: The algorithms and processing techniques developed under this effort potentially will be useful in military systems requiring autonomous stand-off detection under stressing conditions of sensor clutter induced by scene structure and the data-collection process, and spectral interferences. It potentially will also be useful for non-military applications involving autonomous detection under similar conditions of scene-induced and sensor-induced clutter and noise and spectral interferences.

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KEYWORDS: imaging, algorithms, non-imaging, data analysis, hyperspectral, ultraspectral, multispectral, data processing

AF99-074 TITLE: Satellite Local Area Network (LAN)

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop and demonstrate architectures, concepts, and hardware for satellite local area data networks.

DESCRIPTION: Trends towards less costly approaches to meet mission requirements have generated new architectures for space systems. One such novel concept is the idea of collaborating clusters, or swarms, of small satellites flying in close formation working cooperatively to do the job of a larger, more complex satellite. Notional missions for these clusters include radar, communications, navigation, and passive radiometry. To effectively perform a complex mission, the small satellites must maintain relative autonomy (attitude and control correction) and share/distribute processing capabilities. A network will be developed that best utilizes existing technologies/hardware (both current-off-the-shelf and developmental). The crosslink (either pulsed or continuous) will be required to connect four to sixteen satellites at close range (less than one kilometer) and satellite clusters at long range (greater than one kilometer). Realize that the arrangement of the satellites is dictated by mission needs, and one satellite may obstruct the line-of-sight of two other satellites. Each satellite will need to communicate with other satellites within the cluster uniquely. The crosslink should be capable of omnidirectional, simultaneous, high data rate communication and be lightweight (under 0.5 kg), low power (less than 1 W), and space survivable (10 years in LEO) for use on a small satellite. The crosslink should also be capable of secure communications either through spread spectrum, frequency hopping, or encryption. The small satellites must be able to effectively communicate at high data rates, up to 250 Mbps, with low bit error rates, less than 1E-6, over a kilometer range and permit the satellites to know their relative positions within an SEP of a foot. Furthermore, the crosslink should not interfere with any mission of the small satellites. One mission of these devices may be an X-band distributed aperture radar. There are several commercial terrestrial versions of similar devices, for computer wireless LANs, that use radio transmitters and receivers and a conventional ethernet protocol (such as TCP/IP). A similar device suitable for spaceborne applications is desired.

PHASE I: Explore concepts and technologies for satellite LAN architectures. Analyze and trade design parameters defining the hardware, software, and operations requirement. Select concepts for more detailed evaluation. Where appropriate, validate key technology concepts by analysis or modeling the architecture or limited component testing and assess the feasibility.

PHASE II:Develop a proof-of-concept prototype. Fabricate and test components by communicating between several systems.

PHASE III DUAL USE APPLICATIONS: The technologies developed here could be implemented in laptop personal computers, fleets of ships or trucks, and commercial LEO communications satellites. Lightweight wireless LANs developed under this SBIR, with about 100 times the speed of commercially available LANs, could be competitive in high-end laptop systems. Availability of these technologies for large military (as well as possible commercial) LEO constellations could also provide cost and weight effective crosslinks for these systems.

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KEYWORDS: network, crosslink, lightweight, high data rate, data transmission, miniature hardware, space communications

AF99-075 TITLE: Development of an Integrated Autonomous Optical Imaging Polarimeter-on-a-Chip

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop a compact intelligent optical imaging polarimeter on a chip that automatically detects and processes optical radiation to determine its polarization state and interpret the result.

DESCRIPTION: The surveillance missions of satellites, satellite constellations and other unmanned space vehicles, requires the development of intelligent optical sensing systems that can detect and interpret optical signals autonomously. Intelligent sensing systems combine the detection processing and control functions of complete optical systems onto a single package such as a focal plane, detector chip or multichip module. One promising application of intelligent optical systems for autonomous satellites is in the detection, processing, and evaluation of polarization imagery. Imagery from the polarization properties of passive radiation emitted and reflected in the short wave, mid-wave and long wave IR has shown potential for improved target discrimination over other IR imaging techniques. (Ref.'s 1-2)
The polarization state of an electromagnetic wave is fully described by a set of four parameters known as the Stokes parameters.(Ref.'s 3-5) Collectively, these parameters comprise the Stokes vector and represent the magnitudes of the unpolarized component, two different linear polarized components, and the circularly polarized component of the radiation. It is the relations between these four parameters that can act as tools for the discrimination of military targets in IR imagery. (Ref.'s 6-10)
Development of an integrated optical imaging polarimeter requires consideration of optical polarization detection hardware in which the polarization state at each pixel in an image is determined. In combination with the polarization state, processing circuitry must be developed to detect anomalous or prescribed polarization signals. To be useful in space applications, systems developed in this program must detect and process polarization information autonomously. Optical and electronic components should be simple and compact, and processing algorithms should be suitable for implementation in onboard processors. Integration of polarization optics and processing circuitry components onto the detector plane is desirable. (Ref.'s 11-13) Exploiting polarization at multiple wavelengths and combining this information with spectral signatures is the logical extension of this autonomous polarimeter chip development program.

PHASE I: Explore concepts and technologies for the design of an intelligent optical imaging polarimeter on a chip. Identify optical detection scheme, polarization processing for determing complete polarization state at each pixel, and concepts for processing to interpret anomalous polarization signal from within a single pixel or from groups or clusters of pixels. Also identify system control and packaging concepts for complete system autonomy. Establish the feasibility of the approach.

PHASE II:Develop a system prototype that demonstrates autonomous imaging polarization detection and processing. Determine and validate key performance metrics.

PHASE III DUAL USE APPLICATIONS: Polarimeter-on-a chip concepts have applications in improved automatic target detection and identification systems in unmanned space surveillance platforms. Technologies developed in this project would be useful for passively detecting potential targets in a wide field of view and cueing an active target designator or other surveillance systems. Technologies developed for this program can also be employed in machine vision and automated non-destructive testing applications.

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KEYWORDS: polarimetry, smart pixels, multichip modules, focal plane arrays, on-board processing, automatic target recognition

AF99-078 TITLE: Self-Aligning High Density Connectors

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop extremely high density electrical connectors that are small and easy to use.

DESCRIPTION: The global need is to develop a connector system that increases the number of contacts that can be made in a given area, as well as eliminating the increased insertion force that typically accompanies an increased number of contacts. The Air Force problem is to decrease the mass and volume of connectors used in space systems, and to accommodate more connections with smaller, lighter hardware. A self-aligning system will not only enable more contacts per area than is possible with current manually aligned connectors, but may also enable future systems for on-orbit robotic repair of electrical systems. Acceptable approaches would employ some form of actuator to align the contact pins as well as to grip the two halves of the connector system together. One approach may be to use shape memory alloy which holds one shape when heated electrically, and another when unpowered. A two-stage approach to alignment may also be necessary, with rough alignment via tapered pins, and final alignment with some active pin-positioning system. The contact pins may be aligned as a whole, as long as the pin-to-pin spacing on both halves of the connector are held rigidly. To meet Air Force needs, the connector system can consume up to 4 watts of power for no more than 5 seconds when engaging, but must be completely unpowered when in the connected or disconnected state. The connector halves must be mechanically interlocked when engaged and unpowered, with no further manual tightening needed. The person making the connection should merely have to bring the two halves together with zero insertion force, and the automatic system should take over for contact pin alignment and mechanical joining of the two connector halves. The pin-to-pin spacing should be no more than 10 mils, with smaller spacing desirable. The design should allow for multiple rows of contact pins and should include a method of bringing the wiring from the cable to the contact pins of the connector.

PHASE I: Prove the viability of the actuation mechanism and develop the fabrication techniques for the actuator(s). Outline the possible connector architecture and methods to be used to ensure contact alignment and mechanical interlock. Concept demonstration can consist of an final-sized actuator moving a mockup contact pin and locking the two connector halves together.

PHASE II:Develop a self-aligned connector system as outlined above, with a clear path toward making the device manufacturable in large quantities. Concept demonstration will be a final connector design with more than 128 contacts making reliable low resistance (less than 0.1 ohm) connections for each of 20 cycles.

PHASE III DUAL USE APPLICATIONS: High density connectors will find a ready commercial market in the growing complexity of computer systems, especially small portable systems with detachable peripherals. Benefits are increased peripheral functionality with decreased dexterity requirements on the part of the consumer. A typical application may be the increasingly popular Personal Digital Assistants (PDAs) which are typically shirt pocket-sized, yet are taking on more functions found in full-sized personal computers.

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KEYWORDS: electronics, microcontacts, microactuators, active alignment, zero-insertion-force, lectrical connectors

AF99-079 TITLE: Micro Alignment Manipulator Architectures (MAMAs)

TECHNOLOGY AREA: Electronics

OBJECTIVE: Integrate Vertical Cavity Surface Emitting Lasers (VCSELs) with Micro Electro Mechanical Systems (MEMs) to produce active alignment architectures for optical fibers or other optical elements.

DESCRIPTION: High speed data transfer in the near and far term poses limitations when using copper or metal-based media. Photonics technology has overcome many of the problems associated with wire-based data transfer. Optical information exchange via the use of high speed lasers, modulators, and fiber optics will continue to play a greater role in managing this ever-increasing data congestion. The introduction of Vertical Cavity Surface Emitting Lasers (VCSELs) offers promise in alleviating these problems. The issue to be addressed in this topic is a need for active alignment of multiple optical fibers to VCSEL or detector arrays.
With advancements in the produceability of Micro Electro Mechanical systems (MEMs), it is projected that the geometry of VCSELs and MEMs could be integrated to form robust optical interconnects for use with singlemode optical fibers or free space board-to-board communications. Currently, the methods for aligning and fixing optical fibers to small active regions of laser diodes or detectors is economical for cases where only several fibers are being coupled. With an increasing number of active elements to be aligned, the issues become technically challenging and costly.
The primary issue is the thermal stability of the alignment structure and how dimensional expansion/contraction affects the ultimate alignment of multiple elements. This dimensional instability problem increases greatly when the fiber being aligned is of the singlemode type. Singlemode fibers typically have core sizes between 5 and 10 microns, which makes the alignment of multiple sites difficult when considering the dimensional thermal instability of a much larger alignment fixture to an active array of emitters or detectors The advantages of singlemode fiber over larger core multimode are many, but in general offer much higher bandwidth which is needed to meet the increasing data volume and transfer rates of future information systems.
The ideas envisioned for the integration of MEMs with VCSELs include active alignment of either fibers, mirrors or lenses to active emitters and detectors. The feasibility of incorporating all on a single substrate poses serious technical challenges. However, the idea of a MEM structure physically translating an optical fiber over several microns offers the packaging community advantages over current methods. Another advantage of the MEMs alignment method is the ability to scale to much larger multi-element configurations. Micro Alignment Manipulator Architectures (MAMAs) offer a solution to the packaging community to economically produce high speed parallel optical networking systems.

PHASE I: 1) Investigate the feasibility of a MEM device to physically manipulate the alignment of an optical fiber to an active VCSEL. 2) Develop a MEMs design that would be capable of performing an active alignment task between a single element VCSEL and a single optical fiber. 3) Fabricate and demonstrate the 1-D design. 4) Recommend a 2-D design for active alignment of multiple elements.

PHASE II:Fabricate and demonstrate the 2-D design recommendation from Phase I.

PHASE III DUAL USE APPLICATIONS: Implement the Micro Alignment Manipulator Architectures to commercial and military products needing active alignment of micron-sized elements.

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KEYWORDS: MEMs, VCSELs, optical fiber, communications, active alignment, data transmission

AF99-082 TITLE: Training for Space Operators Using a Distributed Mission Training Environment

TECHNOLOGY AREA: Human Systems Interface

OBJECTIVE: Provide Distributive Mission Training capabilities to support the warfighters and space operators in performing their mission more efficiently and effectively.

DESCRIPTION: Develop a Distributed Mission Training environment through simulation technology to enhance the training of space operators and warfighters. The phased approach will provide a complete assessment and evaluation of the advanced simulation and training requirements needed to accommodate team distributed training for space operators and warfighers. The identification of potential technology improvements capable of accommodating the advanced training for AFSPC operators and warfighters is essential for developing and refining the requirements for virtual, live, and constructive modeling and simulation for the DMT environment. With a fully capable environment for implementing DMT, new technologies will be designed and developed for a distributed mission training testbed for team training. Assessment and evaluation of the DMT testbed will validate the mission training technology applications.

PHASE I: Phase I will result in a proposed proof-of-concept technology to support team distributed training for space operators and warfighters. Assessment and evaluation data for advanced simulation technologies will enhance mission objectives of space training directly related to mission, training tasks, team participants, combat tasks, adversaries, and theater procedures. Task measurements for assessing space operator and warfighter team training integration include those related to training in combat and the evaluation of mission preparedness. Two domains will be assessed for testing. One domain will be space related specific to the military team environment such as mission planning. One will be related to a non-military domain such as NASA or to a commercial enterprise such as regional sales teams or product development teams.

PHASE II: Phase II will fully develop, refine, test and evaluate the requirements for virtual, live, and constructive modeling and simulation to support a distributed mission training environment for space operators and warfighters. Additional activities in Phase II include specifications for a demonstration of virtual, live and constructive combat based scenarios in a DMT environment with a space-based operator at one site interacting with warfighter(s) at a separate site. Document analytical evaluation of testbed application of DMT. Document description of simulated data. Proposals should assume that the technology will run in a platform-independent environment.

PHASE III DUAL USE APPLICATIONS: This effort will provide a cost-effective capability to implement high fidelity, multi-role, interactive training and system integration. The results of this effort have high value to the Public Sector as group and team training at distributed sites becomes essential. Phase III Dual Use potential is significant as no other technology exists that provides an intelligent-linked, scenario-driven, performance-based team training capability supporting live, virtual, and constructive events. Applications of this technology are highly innovative and would benefit both the Government and Public Sector to reduce cost-prohibitive development of environments for training and performance assessment.

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KEYWORDS: Team Integration, Space Superiority, Intelligent Systems, Performance Measurement, Battlefield Environments, Advanced Simulation Training, Distributed Mission Training

AF99-083 TITLE: Modeling and Simulation of Less Than War Scenarios

TECHNOLOGY AREA: Manpower, Personnel, and Training

OBJECTIVE: Develop a simulation which can measure the ability of alternative force packages to deter combat in an Operations Other Than War (OOTW) scenario.

DESCRIPTION: The evaluation of modernization initiatives in acquisition decision making has centered around modeling and simulation of Major Regional Conflict (MRC). These types of conflict are, for example, representative of the Desert Storm operation. However, there is a high probability that U.S. forces will be involved in OOTW. In the future, systems, which can contribute to the mission of preventing combat, will become increasingly important. It has long been held that weapon systems and technologies that successfully compete at the higher levels of war will be able to treat the "less-than-war" situations. Alternatively, there is a view that systems, which can deal with the problem of peacekeeping and deterrence, might not show a lot of promise at the MRC level of conflict. Whereas, major regional conflicts primarily deal with participant's kills/losses and territory gained or lost, OOTW deal with

different metrics and objectives such as time delays, efficiency, or controlling a situation. Methodologies and software are needed to quickly build and assess the outcome of OOTW scenarios in order to evaluate promising technologies, systems and tactics.

PHASE I: Develop a prototype methodology/software and perform a feasibility demonstration for modeling OOTW.

PHASE II:Extend prototype into a fully functional OOTW simulation, and apply the simulation in historical and future scenarios.

PHASE III DUAL USE APPLICATIONS: High commercial applicability in the areas of military planning, drug, immigration, and law enforcement. The vendor will be able to market software to both government and civilian commercial companies. Government agencies will include federal, such as Department of Defense (DoD), as well as state and local governments.

REFERENCES:
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KEYWORDS: Deterrence, Simulation, Peacekeeping, Alternative Force, Operations other than War

AF99-084 TITLE: Next Generation Distributed Joint Aircrew Training Effectiveness

TECHNOLOGY AREA: Human Systems Interface

OBJECTIVE: Develop innovative evaluation models and tools for Air Force instructors to use for interactively evaluating Joint Distributed Mission Training, wargaming analysis, training evaluation feedback, etc.

DESCRIPTION: Research computer algorithms, including object-oriented technologies, which will apply training information provided by various Aircrew training courses, Joint Distributed Mission Training simulations, wargame exercises, etc. to aid decisions concerning how training results can be used in training forecast models. Identify the information required from training exercises, simulations, and simulators for input to evaluation algorithms that measure aircrew and team performance in either flight simulators or actual flying training. Identify or develop innovative tools, methods, and metrics, which support training evaluation and analysis, creation or linking of course instruction to domain analysis, and developing repositories for training effectiveness data reuse. Research cost-effective ways to link live flight training and flight test analysis data in order to develop and validate flight simulator training. Unique and innovative applications of existing commercial tools will be considered. PHASE I: Describe the proposed new concepts in detail, including a description of their viability and feasibility and recommendations regarding which appear most promising. PHASE II: Develop and demonstrate a working prototype tool or software program.
Evaluate the tool or program and document the evaluation effort in a report.

PHASE III DUAL USE APPLICATIONS: All solutions must have potential for dual-use/application in the commercial as well as military sector. Potential commercial applications must be identified and discussed in the proposal.

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KEYWORDS: Aircrew Training, Training Evaluation, Training Development, Distributed Training

AF99-085 TITLE: Low-Cost Collimating Screen Materials for Out-the-Window Simulator Displays

TECHNOLOGY AREA: Manpower, Personnel, and Training

OBJECTIVE: Develop low-cost collimating screen for out-the-window simulator displays.

DESCRIPTION: This topic calls for advances in collimated, rear-projection, flat and/or curved (in one or two dimensions) display screen technology. Screen technology developed under this project will be used in enhanced versions of the Mobile Modular-Based Display for Advanced Research and Training (M2DART) and other applications requiring low-cost collimated displays. The M2DART is a flight simulator visual display developed at the Human Effectiveness Directorate/Warfighter Training Research Division (AFRL/HEA). In its current design, the M2DART uses commercial off the shelf projector technology and eight flat, rear projection screens tiled together to present a 360o wrap-around out-the-window scene. The horizontal field-of-view (FOV) for each of the 8 window screens varies between 72 and 82 degrees. The screen normals are positioned at a 36 inch viewing distance from the design eyepoint. Future enhancements to the M2DART also include high resolution laser based projectors currently under development. Display screens developed under this project must: be low-cost; be thin (less than 3 inches in thickness); allow for either CRT or laser based rear projection of imagery; enable tiling of multiple screens; have minimal distortion, optical aberration, lune, and ghosting effects; be light weight; have a large exit pupil; and have high transmissivity.

PHASE I: Provide a technical report determining feasibility of the concept and provide a demonstration of the feasibility.

PHASE II:Phase II will result in prototyping and testing display screens proposed under Phase I and a technical report.

PHASE III DUAL USE APPLICATIONS: Commercial training for flight, automobile, and other simulator environments.

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KEYWORDS: Projector, Simulator, Collimated, Visual Display, Rear Projection

AF99-086 TITLE: Advanced Controls and Displays for Space Operator Consoles

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop concepts and a testbed for next-generation space operator consoles using multi-sensory display and alternative control technology

DESCRIPTION: Although the Air Force Space Command (AFSPC) has an ongoing series of modernization programs such as REACT (Rapid Execution and Combat Targeting), space operator consoles that support communications, early warning, surveillance, and spacelift operations are in many cases based on outdated control and display technology. Even the modernized consoles do not take advantage of recent advances in multi-sensory displays and alternative controls. Current Air Force Research Laboratory (AFRL) programs have emphasized the application of these technologies to cockpit and aircraft command and control environments. These technologies offer equal payoffs for space operations. The ultimate goal will be to enhance the effectiveness of our "guardians of the high frontier" and to transfer these technologies to a variety of commercial and military aerospace environments.

PHASE I: With the guidance and assistance of AFRL and AFSPC: (1) Identify next generation control and display needs for space operations. (2) Identify candidate space operator consoles or control centers where incorporation of these technologies is likely to produce the highest gains in system effectiveness. (3) Select from these candidates a subset that can be incorporated in a research and technology demonstration testbed in Phase II. Several criteria should guide this selection process. The proposed control and display enhancements should be sufficiently mature to support operational test and evaluation within 5 years of the completion of Phase II. Examples include localized (3-D) audio, haptic (force) guidance and feedback, head-mounted immersive displays, speech recognition, head and eye tracking, and gesture recognition. The functions performed at the selected console(s) should be critical to several elements of space operational effectiveness. To the maximum extent possible, console functions should have elements in common with commercial space, commercial aircraft, and uninhabited aerial vehicle control operations. This will enhance the technology transfer and commercialization aspects of the program. A desired Phase I product is a computer-based rapid prototype that clearly illustrates the consoles(s) chosen for the testbed and the advanced control and display technologies to be incorporated

therein. The Phase I report should provide a detailed description of the operator tasks normally accomplished with the console, concepts for integrating the new control and display technology, and an analysis of the anticipated operational payoffs.

PHASE II:Develop a fully functional space console testbed for evaluation and demonstration of the new control and display technologies. It is highly desirable that the testbed be compatible with Distributed Interactive Simulation (DIS) protocols so that it might, in the future, be interlinked with other elements of a DIS network. The Phase II testbed should support the inclusion of space operations models so that mission and operator effectiveness measures can be employed during the Phase II evaluations.

PHASE III DUAL USE APPLICATIONS: The technology developed in this program will be applicable to a wide range of communication and aerospace operator control consoles. Potential application environments include NASA, FAA control centers, commercial space operations, and government and commercial communication control centers. Phase II or III dual-use alliances with these organizations are encouraged and highly likely.

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KEYWORDS: Localized (3-D) Audio, Space Operator Consoles, Multi-Model Interaction, Haptic (force) Guidance

AF99-087 TITLE: Imagery Analyst Interface for Ultra-Spectral Imaging Sensors

TECHNOLOGY AREA: Human Systems Interface

OBJECTIVE: Identify, develop, demonstrate and assess the utility of innovative intelligence imagery analyst-display interfaces, based on visual psychophysics, which are applicable to multispectral imagery.

DESCRIPTION: Human capability for exploiting and analyzing the ever increasing volumes of multi-(and hyper-/ultra-)spectral images is limited. For example, space- and airborne imagery sources are increasing in number without a corresponding increase in the number of human image interpreters. (In fact, there is serious concern regarding the decrease in both the number and experience level of military imagery analysts.) For example, multi-spectral images are increasingly available, but no standard for human viewing of multi-spectral images has yet been developed. Both the military and commercial sectors have made large investments in algorithms for the automated exploitation of multi-spectral imagery. Many of these algorithms employ non-intuitive computations (such as the ratio between pixel intensities in specific wavelength bands or pattern recognition schema employing neural networks). The human analyst is provided with no capability to verify the results of the automation. These problems will only be exacerbated as hyper- and ultra-spectral imaging systems continue to mature. This topic seeks proposals to discover new image display processing and operator interface technologies based on human and biological image processing. Human and other biological systems are known to process images in multiple spectral bands that are held in registration during target recognition and navigation. Further, many of the processing steps of human vision are known and have been formally described, often in terms of algorithms for image processing. This topic encourages the extension of algorithmic descriptions of human multi-spectral image processing to the domain of image display processing. The overall technology objective is a display of (fused and/or otherwise preproceesed) multi-spectral images with measurable advantages for human tasks of interpretation, orientation, and information extraction. Secondary technology objectives include real-time image processing, feature and target segmentation, and wearable, head-mounted, displays. Technology challenges include: (1) spatial registration of multi-spectral static and moving image streams, (2) dynamic range compression or normalization to prevent display saturation, (3) false coloring of fused images for improved human image segmentation and target recognition, (4) benchmark tasks to enable quantitative comparison of various solutions to problems of human image processing performance in recognition and exploitation. For purposes of this topic, multi-spectral is intended to also include polarimetric images within a single spectral band or non-image data that may be fused with image streams.

PHASE I: Produce a proof-of-concept. Identify realistic current and future multispectral imaging sensor system capabilities and operational concepts. Identify and investigate multispectral imagery exploitation tasks and associated information requirements. Develop and implement a proof-of-concept demonstration and assessment plan.

PHASE II:Develop and demonstrate a prototype system capable of operating under realistic conditions of sensor coverage rates, number of electromagnetic spectral regions/bands, fusion and other operator aiding subsystems, and essential elements of information to be satisfied.

PHASE III DUAL USE APPLICATIONS: Military uses of this technology include concealed target detection, materials properties analysis, hydro- and hypsographic analysis, counter-proliferation and counter-terrorist operations. Multispectral sensing has dual use/commercial application in exploration for petroleum and minerals, land-use quantification, crop surveys, law enforcement as well as pollution and environmental monitoring.

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KEYWORDS: Fusion, Sensors, Monitoring, Surveillance, Reconnaisance, Remote Sensing, Earth Resources, Imagery Analysis, Image Enhancement, Visual Perception, Imagery Exploitation, Hyperspectral Imaging, Ultraspectral Imaging, Multispectral Imaging, Human System Interface

AF99-088 TITLE: Path Intercept Trajectory Algorithm

TECHNOLOGY AREA: Human Systems Interface

OBJECTIVE: Develop a real-time, adjustable intercept path algorithm to guide pilots back to a predefined path.

DESCRIPTION: Work continues at the Air Force Research Laboratory, Human Effectiveness Directorate on format and display of a head-up pathway in the sky (a.k.a., "Pathway") for use as a primary flight reference (Reising, Liggett, Solz, and Hartsock, 1995). The Pathway depicts a preplanned route to some desired endpoint (e.g., touchdown or weapon delivery). The problem consists of directing a pilot back to this predefined path once he or she is somehow diverted. The solution includes an algorithm (and associated display) capable of guiding the pilot back to the Pathway when it leaves the pilot's field of view. While the symbology associated with such an intercept path is now available, the underlying algorithm itself is not. Such an algorithm must run in real-time (i.e., be available to the pilot at the push of a button), lead the pilot back to the predefined path as quickly as possible, and be adjustable to accommodate variable specification of a variety of intercept path parameters. These parameters include minimum terrain and obstacle clearance, maximum bank angle, maximum Gs pulled, maximum pitch angles, and airspeed. The solution must be general enough to allow accommodation of a variety of aeromodels (e.g., fighter and transport aircraft) and must be as flexible as possible in accommodating starting speed, altitude, heading, attitude, and other flight parameters of the aircraft when the intercept path is generated.

PHASE I: Generate a design for the desired intercept trajectory algorithm. Define the algorithm's specifications and requirements, to include the hardware/software architecture necessary to have it respond to the pilot in real time.

PHASE II:Based on the products of Phase I, program and implement the desired algorithm. Phase II should result in a turn-key, open-system product suitable for immediate use in flight simulation and research.

PHASE III DUAL USE APPLICATIONS: The value of pathway-in-the-sky displays is now widely accepted by the aviation community. One indication of this is NASA's intent to spend over $10 million in the next several years to fund research and commercial development of these displays as part of its Aviation Safety program. In addition to certification, one of the few issues remaining as an obstacle to inclusion of these displays in civil aviation cockpits is the question of what to display when a pilot leaves the commanded path. An intercept algorithm of the type described above would have direct application in the solution of this problem and, as such, would be commercially transferable to any of the companies now investigating and designing pathway-in-the-sky displays for use in civil and general aviation cockpits.

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KEYWORDS: HUD, Pathway, Intercept Algorithm, Primary Flight Imary, Primary Flight Display, Flight DOD Critical Technology

AF99-089 TITLE: Human Representation in System Requirements Definition Process

TECHNOLOGY AREA: Battlespace Environments

OBJECTIVE: Authoritative human behavior representation explicitly linking human performance and system effectiveness in constructive system analyses.

DESCRIPTION: In general, the representation of humans in constructive simulations is extremely limited. Decisions made early in the weapons systems acquisition process are typically without benefit of adequate consideration of the human. There is a need for representing the human interaction with complex automated systems in a way that will provide meaningful information to decision-makers involved in this process. The project will produce a technology for representing the behavior of individuals and teams, and for yielding explicit, operationally-credible, human-performance measures that can be directly linked to system effectiveness measures in engagement and mission-level constructive analyses. The scope is a technique for defining the limits of human performance that must be supported by the system interface (e.g., "the human interface must allow the operator to identify the target in less than two seconds, at a range of...") in order to satisfy overall system effectiveness objectives given the environment and other system performance parameters (and vice versa); it is not intended for defining the interface itself. The product will provide a capability for describing tasks and activities, information requirements, and human adaptability and variability in decision making to the extent necessary to support this end. Similarly, the product will account for constraints imposed by workload, such as the trade-off between time-to-perform and accuracy of performance. The technology advanced by this work will support the development of tools that represent human behavior in constructive models employed in the Analysis of Alternatives process, as well as in trade studies required to develop mission needs statements and operational requirements documents. As such, it must be demonstrably compatible with the DoD High Level Architecture (HLA). Users of this product are members of the acquisition and requirements communities who must make acquisition decisions based upon the anticipated performance of humans and weapons systems operating together. Human behavior representation, as referred to herein, means a computer-based model that mimics -- but does not necessarily replicate -- the behavior of either a single human or the collective action of a team of humans.

PHASE I: A descriptive framework will be completed. A final report will document issues, the framework, reviews, progress, and associated findings.

PHASE II:A breadboard will be developed and evaluated for a given military-based application. This breadboard will provide a demonstration of: (1) a capability to integrate representations of human performance into engagement and mission-level constructive simulations, (2) a capability to appropriately represent shifts in human-system goal states in response to changing demands in a mission environment, (3) human performance measures that trace the shifting goal structure and the human's ability to recognize a goal change, and then adapt performance accordingly, and (4) a performance assessment structure that links measures of human performance to system measures of effectiveness. A final report will document issues, needs and requirements, tradeoffs, problems, and findings.

PHASE III DUAL USE APPLICATIONS: This product is applicable to the conceptual design of any complex system that includes human components, so long as constructive representations of the system and environment exist or can be developed. Examples include: nuclear power plants, air traffic control, air and space craft, space mission control, metropolitan emergency management, and police command and control units.

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5. Defense Modeling & Simulation Office (DMSO), Human behavior representation, http://www.dmso.mil/projects/hbr/

KEYWORDS: Modeling, Simulation, Performance, Effectiveness, System Design, Human Interaction, Constructive Model, Use-Centered Design, Human Centered Design, Human-System Interface, Human Performance Model, High-Level Architecture, Analysis of Alternatives, Human Behavior Representation

AF99-090 TITLE: Advanced Multifunction Head-Up Display (AMHUD)

TECHNOLOGY AREA: Human Systems Interface

OBJECTIVE: Develop advanced head-up display (HUD). Potentially integrate multifunction capability.

DESCRIPTION: There is a need to overcome technology barriers that prevent smaller, lighter, cheaper, more reliable HUDs of classical monochrome design from being manufactured. Also, it may be possible to combine a HUD light engine within a color head-down display (direct view or projection). Reliability improvements will significantly reduce expensive HUD maintenance actions. Present day HUDs use cathode-ray-tubes (CRTs) to produce the image. These CRTs consume high power at high voltage, have poor reliability, are subject to the vanishing vendor syndrome (VVS), and give an image with a line split, requiring an expensive dichroic optic system. Emerging display technologies may significantly improve the imaging source and eliminate some or all of the problems associated with the CRTs. Also, the optics might be designed with diffractive optics to significantly reduce the volume of present day HUDs, which presently jut into crew spaces making cockpit design, including ejection systems, extremely complex. An advanced HUD of classical functionality (compared to a present day HUD) would require 25 percent as much volume (0.5 vs. 2 cubic feet now), use 50 percent as much power, operate on lower voltage (28 V vs. about 10,000 V for CRTs), have half the weight (30 vs. 68 lbs. now), have an initial purchase cost of half as much ($85K vs. $170K), with 10X greater MTBF (2000 hr vs. 200 hr now).

PHASE I: Phase I is expected to result in a manufacturable design which takes into account reliability and maintainability issues for environments typical aircraft installations.

PHASE II:Phase II is expected to result in a prototype AMHUD to be delivered to the Air Force Research Laboratory for evaluation. The contractor may use feedback from these evaluations to refine a production design.

PHASE III DUAL USE APPLICATIONS: Displays are the quintessential dual-use technology. Military applications of AMHUD include the Air Force and other DoD aircraft. For example, the F-16 plans to initiate a program to replace the HUD with a new design in about 2003. Commercial applications include commercial airliners. Many airlines are fitting their aircraft with HUDs to give them access to airfields in bad visibility, thereby gaining a competitive edge. Civil aircraft fitted with HUDs are being certified to CAT III allowing them to land in almost zero visibility. The successful completion of this project could make HUDs viable for all types of military and civil aircraft. Similarly, the automotive industry is interested in installing advanced HUDs in production automobiles. Head-Up Displays are not now fitted in many aircraft (nor in most automobiles) primarily because of their high cost, size, and weight.

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KEYWORDS: Power, Electro-optics, Electron Devices, Information Fusion, Information Display, Crew Station Integration, Integrated Platform Electronics

AF99-091 TITLE: Advanced Virtual Human Sensory Interfaces

TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Enhance operational Air Force through integration of human sensory feedback with virtual reality.

DESCRIPTION: A requirement exists for effective human performance and telepresent system controls that are based on natural, intuitive interfaces using innovative abilities and requiring no learning or training for efficient operation. The intuitive interfaces facilitate operator task performance, lessen mental and physical workload, reduce fatigue, and improve personnel safety. These intuitive interface technologies include, but are not limited to: 1) natural stimulation for perception of remotely-sensed tactile information, 2) high-fidelity force-reflecting haptic interface devices, 3) perceptually-driven control methods for teleoperated systems, 4) integrated hardware/software to superimpose position-calibrated virtual reality models with real-time video imagery, and 5) efficient computational algorithms for synthesizing interaction forces between virtual objects in a virtual environment. Innovation is needed in order for these technologies to be effective in remote and/or high-stress environments characteristic of military operations. This topic represents an opportunity for innovative ideas to be applied to individual components, the integration of multiple components, and the application of these to address current Air Force and DOD deficiencies in man-machine interfaces. These issues will be even more important in the future within the reduced force structure environment. A single interface issue or

any combination of interface issues may be addressed in the offeror's proposal.

PHASE I: Phase I efforts would provide an assessment of the state of the art and an approach to develop an appropriate intuitive interface technology.

PHASE II: Phase II efforts would provide a demonstration and validation of the intuitive interface technology.

PHASE III DUAL USE APPLICATIONS: Commercial applications of these technologies are possible in the commercial aviation, entertainment, industrial safety, and health care fields, as well as in telemedicine, environmental cleanup, and nuclear facility operation.

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KEYWORDS: Telesurgery, Telerobotics, Telepresence, Exoskeletons, Remote Surgery, Virtual Reality, Telemanipulation, Tactile Feedback, Force/Torque Feedback, Synthetic Environments, Operator-Robot Interface, Human-Machine Interaction

AF99-092 TITLE: Compact Ultrashort Laser Sources

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Develop a commercially viable ultrashort laser pulse source.

DESCRIPTION: Ultrashort laser pulses have enormous potential in commercial, industrial, medical and aviation applications. However, present ultrashort laser sources are essentially laboratory developmental units requiring a relatively large space and a well-controlled environments. Research is needed to build an ultrashort laser system that is very compact and requires minimal maintenance for continued short-pulse production. An initial assessment will determine the possibility to build such a laser system in a 2-foot by 2-foot by 3-foot housing, with all material internal, with the possible exception of the power supply.

PHASE I: Phase I will result in the determination of feasibility, technical design and proof-of-concept for the compact ultrashort laser source.

PHASE II:Phase II will develop a prototype turn-key laser system which will produce very large energy laser pulses (e.g. greater than 5 mJ per pulse) shorter than 500 femtoseconds in duration.

PHASE III DUAL USE APPLICATIONS: Research is presently discovering the ability of ultrashort laser sources to effectively machine to dimensions smaller than the optical diffraction limit. In addition, commercial applications such as paint removal, thin coat deposition and medical diagnosis and treatment are well within technical achievement and will be facilitated by the availability of compact laser sources.

REFERENCES: M.D. Shirk and P.A. Molian, A review of ultrashort pulsed laser ablation of materials, Jour. Laser Applications Vol. 10, No. 1, 18-28 (1998).

KEYWORDS: Compact Lasers, Ultrashort Lasers, Femtosecond Lasers

AF99-093 TITLE: Advanced Battery For Head and Helmet Mounted Night Vision Devices

TECHNOLOGY AREA: Human Systems Interface

OBJECTIVE: Develop an environmentally benign battery to power night vision devices in extreme cold.

DESCRIPTION: Night vision device batteries are required to provide the proper current and voltage to power one, two, or even four

image intensifier tubes for long periods of time at extreme temperatures. The batteries currently available that can meet this requirement are large, heavy, not readily available, expensive, and/or present an environmental hazard when discarded. To improve the quality of the night vision device human system interface, this effort will focus on the design, fabrication, assembly, and testing of a single, compact battery which can reliably power an aviator's night vision device, the AN/AVS-8, at low temperatures for at least six hours and pose no environmental hazard upon disposal. The dimensions and weight of batteries resulting from this research will be no greater than the dimensions and weight of the common AA alkaline battery (goal of less than or equal to the 1/2 AA battery). Battery designs will be required to provide at least 55mA at 2.0V or greater for at least six hours at -34 degrees Celsius. A tester integral to the battery should also be included in the design.

PHASE I: Research will result in a design that takes into account the power, size, weight, environmental, and reliability requirements mentioned above and is ready for fabrication and assembly. The design will include any support equipment required to maintain the battery in the field and address issues surrounding interfacing the battery with current night vision devices. Delivery of a laboratory demonstrator prototype at the end of Phase I is highly desirable.

PHASE II:The design from Phase I will result in several prototype batteries, support equipment, and any required apparatus for interfacing the battery with existing night vision devices. The contractor is expected to participate in testing and to receive feedback from the Air Force for a possible future production version of the design.

PHASE III DUAL USE APPLICATIONS: Long life, environmentally benign batteries would have great commercial potential. They would generate large cost savings in both civilian and military markets by reducing the frequency of battery replacement and eliminating the need for special disposal procedures. Advances in low temperature battery life would yield even greater improvements in battery performance at room temperature, significantly increasing battery life over current commercially available products. Replacing high power density and rechargeable batteries (lithium and NiCd batteries, for example) with the device resulting from this research would also eliminate the environmental hazards posed by improper disposal.

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KEYWORDS: Current, Voltage, Battery, Head Mounted, Cold Weather, Light Weight, Night Vision, Battery Life, Helmet Mounted, Night Vision Goggle, Night Vision Device, Image Intensifier Tube

AF99-094 TITLE: Development of Life Support Ensemble Utilizing Smart Materials

TECHNOLOGY AREA: Biomedical

OBJECTIVE: Develop fully integrated life support ensemble, including partial pressure suit and mask tensioning devices, from newly developed smart materials.

DESCRIPTION: Current aircrew life support ensembles utilize air bladders to provide counter-pressure for mask tensioning, +Gz protection, and altitude protection. These bladders can be cumbersome, bulky, and uncomfortable to the pilot during tactical maneuvers. Air bladders also present a filtering/contamination problem in the chemical/biological defense environment. A suit composed of contractile fibers or sheets of "smart materials" would decrease the equipment weight and bulk. Smart materials can be used as sensors, actuators, and as control mechanisms. These materials have superior strength-to-weight ratios and have the potential to provide greater protection to the pilot than current life support systems. Hydrogels, which swell and contract in response to the degree of ionization, could be used in ear-cup and mask seals. Nitinol, a type of shape memory alloy, contracts when an electrical current is applied. This material could be woven into a fabric and used as either a counterpressure garment or as a mask tensioning device. Other smart materials, such as silver-coated nylon, might also be utilized in a life support equipment ensemble. Benefits which might be realized by using smart materials include less weight, greater compatibility with chemical and biological defense ensembles, less mobility restrictions, and reduced heat stress. A fully integrated "smart" life support ensemble, which provides superior mask tensioning, helmet stability, and mechanical counter-pressure would greatly improve pilot performance and protection.

PHASE I: Phase I will result in (1) identification of necessary mechanical and material properties needed to construct a life support ensemble out of smart materials, (2) an assessment of current smart material technology and how well they meet the criteria established in Part 1, (3) recommendations on critical areas of materials research that should be pursued, and (4) preliminary conceptual drawings of proposed life support equipment.

PHASE II:Phase II will result in life support ensemble prototypes that could be used in human test evaluations.

PHASE III DUAL USE APPLICATIONS: Primary market for this technology is in military aviation. Some of the technology developed in this effort could also be applied to commercial respirators, the deep sea diving community, and to counterpressure garments to counteract low blood pressure. Smart systems also have potential use in a variety of sports equipment, including bicycle and football helmets, exercise clothing, and compressive bandages after injury.

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KEYWORDS: Oxygen Mask, G-Protection, Counterpressure, Smart Materials, Partial Pressure Suit

AF99-095 TITLE: Altitude Decompression Sickness Risk Assessment Computer (ADRAC)

TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop software/hardware for the Altitude Decompression Sickness (DCS) Risk Assessment Computer (ADRAC) based on validated models developed at AFRL/HEPR.

DESCRIPTION: The Air Force has an interest in determining the risk of altitude decompression sickness and seeks development of a software package, a hand-held ADRAC, and a panel-mounted indicator. The software will use the existing, computerized, AFRL model of DCS risk which is statistically based on AFRL research data and mathematically based on a system of partial differential equations describing bubble growth. High altitude exposure in aircraft, hypobaric chambers and with extravehicular activity (EVA) in space results in an inherent risk of decompression sickness (DCS). In the past, general guidelines for safer altitude exposures have been developed through costly, time-consuming studies, each specific to unique scenarios of altitude exposure. Rapidly changing technology in aircraft design and mission requirements e.g., high altitude air drops, demand improved capabilities in predetermining and immediately determining an individual's decompression risk assessment. Unlike the diving community, a standardized method for altitude decompression sickness risk determination does not presently exist. In 1990, a new bubble growth algorithm and a statistical model based on the existing DCS Database were initiated at Brooks AFB. The first version of this combined model was completed in 1996 and several papers have been submitted for publication. The model is being validated and is expected to be available in January, 1999. Information on the data required for a proposal may be obtained by calling the author. At that time, an updated version of the model, based on the validation, will be produced and software development can be initiated. Utilization of such software and hardware is anticipated in cockpits, in hyperbaric chamber control stations, in EVA suits, in commercial and private general aviation aircraft, as well as mission planning computers for high altitude operations. Applications of this technology would specifically aid aviators, special operations personnel, and civilian aviators/passengers in determining altitude decompression sickness risk.

PHASE I: Develop a software package/disc based on the AFRL model of altitude decompression sickness risk assessment. The risk assessment output will be a percentage of risk or prebreathe time to reduce the risk to zero.

PHASE II:Develop a hand-held Altitude Decompression Sickness Risk Assessment Computer (ADRAC) and a panel-mounted ADRAC for aircraft using the resulting software package developed in Phase I. The panel-mounted ADRAC will use inputs from the pilot and cabin pressure as provided by an aircraft system. The panel-mounted ADRAC will provide percentage of risk as a product and would alert the pilot via the Master Caution system.

PHASE III DUAL USE APPLICATIONS: Some civilian aircraft have the capability of reaching altitudes up to 30,000 feet mean sea level (MSL) unpressurized and even up to 50,000 feet MSL with pressurized cabins. Balloonists and parachutists also reach into these potentially hazardous flight levels. An ADRAC computer/panel simple indicator light (LCD) could warn these aviators of different decompression sickness risk assessment levels; e.g., green (safe), yellow (increased risk), and red (dangerous risk) via the Master Caution system. Currently available hypoxia (lack of oxygen) models could be integrated into these units so that civilian aviators could determine their risk of altitude hypoxia.

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3. Kannan, N. Petropoulos, L.J., Raychaudhuri, A. Pilmanis, A.A. (1977). An altitude decompression sickness risk assessment model. Aviation Space Environment Medicine. 68:625.
4. Kannan, N. Raychaudhuri, A., (1997) Survival models for predicting altitude decompression sickness. AL/CF-TR-1997-0030,

1997. Unclassified/Distribution Unlimited.
5. Kannan, N., Raychaudhuri, D.A., Pilmanis, A.A., Logistic models for altitude decompression sickness. Aviation Space Environment.

KEYWORDS: Hypoxia, Decompression, Denitrogenation, Risk Assessment, Decompression Sickness, Decompression Computer, High Altitude Protection, ADRAC (Altitude Decompression Sickness Risk Assessment Computer)

AF99-096 TITLE: Distributed Team Knowledge Representation and Scenario-Based Performance Evaluation Methods

TECHNOLOGY AREA: Manpower, Personnel, and Training

OBJECTIVE: Develop collaborative methods for identifying,eliciting and representing knowledge and core competencies for training and performance support and for deriving and scoring task-based scenarios for assessing team performance and readiness.

DESCRIPTION: Recent advances in distributed methods for training, simulation, and performance support demonstrate that it may be feasible to develop an online (near real-time) capability to decompose elements of work activity into knowledge- and competency-based components. Such a capability will permit near-real-time knowledge elicitation and specification for developing models of expertise and for identifying key aspects of performance required to meet mission requirements. Research on team performance assessment has underscored the importance and difficulty of specifying the criterion performance space and the gathering of detailed objective situations related to the performance of teams. Also recent efforts to develop high fidelity performance assessment methods for aircrew members have demonstrated the importance of situationally-based criterion measures for performance and readiness enhancement. However, generating and scoring scenarios for use in assessment has been prohibitively expensive. This effort will develop distributed methods for identifying and eliciting the knowledge and competency-based representations of work activities. Current methods for obtaining knowledge representations are inefficient and time-consuming to implement. Therefore this effort will develop distributed methods for determining knowledge and competency requirements for individual and team work tasks. This effort will also develop and validate methods to generate work sample scenarios to systematically assess the performance and readiness teams. The criterion performance measures are situationally-based assessments from which actual test scores would be obtained. A distributed method for generating scenarios, to be used as task-based work-sample performance instances, will be developed and tested. These high fidelity assessments not only provide critical information about how all members would perform in the given situation, but the data on their responses can be used to identify innovative solutions, misconceptions about the appropriate solution, and incorrect information that could be addressed in follow-on education and training programs.

PHASE I: Phase I will result in a proof-of-concept technology for representing knowledge and competencies to drive training and performance support development. It will also provide a baseline methodology to generate scenarios and prototype scoring algorithms for performance assessments in distributed environments. Exemplar scenario-based criterion measures and data generation methods will be demonstrated in two domains. The domains will be related to military team performance such as mission planning and performance and to non-military domains such as regional sales teams or product development teams.

PHASE II:Phase II will fully develop, apply, test, refine, and validate the knowledge elicitation and representation methodology and will develop a distributed scenario generation and scoring technology to assess workgroup and team performance and readiness. Proposals should assume that the technology will run in a platform-independent environment.

PHASE III DUAL USE APPLICATIONS: This effort will produce a cost-effective capability to elicit and identify core knowledge and competencies required by teams and will develop a near-real-time capability to generate and score scenarios for use in performance and readiness assessments teams. The results applicable to industry as competency-based selection, placement, and training approaches become commonplace with increased job enlargement and workforce globalization. The developed capability will provide the means to efficiently and reliably gather important knowledge information for specifying job, training and performance support requirements. In addition, scenario-based performance assessments offer companies with tools to accurately identify areas of high performance, areas of potential problems, and additional education, training, or management requirements. The benefits from such a capability to Government and Private Sector agencies could help organizations save considerable time and expenditures by targeting selection, training, and measurement to address specific, situationally-relevant areas of performance and productivity.

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4. Kraiger, K., Ford, J.K., & Salas, E. (1993). Application of cognitive, skill-based, and affective theories of learning outcomes to new methods of training evaluation. Journal of Applied Psychology, 78, 311-328.
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KEYWORDS: Program Evaluation, Team Effectiveness, Readiness Evaluation, Criterion Development, Performance Enhancement, Performance Measurement, Workgroup Effectiveness, Competency-based Assessment, Knowledge Elicitation and Representation

AF99-097 TITLE: Training Management Decision System for Team Training Evaluation and Tracking

TECHNOLOGY AREA: Manpower, Personnel, and Training

OBJECTIVE: Design, develop, and demonstrate a training management system for scheduling and tracking of C3I team training and provide systematic evaluation capabilities using intelligent agents and expert systems technology.

DESCRIPTION: Training budgets in all military services are undergoing massive cuts at a time when training is more essential than ever before in our history. Initial and sustainment training of active duty, guard, and reserve warfighters poses major problems and challenges to the military services. Training warfighter personnel in academic schools (ground-based training), simulator training, flight training, and on-the-job training requires scheduling, tracking and systematic evaluation of individual and team performance. Field commanders and supervisors must know who has the requisite training in order to identify the most appropriate individuals or teams to be deployed to the field. Scheduling and tracking students is a major issue especially for guard and reserve units that also must meet the same training requirements as active duty. All training programs, whether lecture or automated, require training management to support individual training and team training evaluation. Most training management systems support maintenance training from an individual perspective. With an eye on the downsizing of the military, team training of aircrews, space operations, and even team training of maintenance personnel is a driving force and primary focus of all military services. An automated means of identifying required sustainment and core-task training requirements and for managing and tracking formal and field (on-the-job) training completion and certification is a critical necessity. The Air Force's present capabilities in scheduling, tracking and evaluation for this type of training are completely inadequate. A training management system must be capable of making decisions in scheduling and tracking performance of individuals as well as teams. Currently, training management systems cannot make decisions and are not conducive to changes with having a system failure forcing instructors to schedule by hand. Some of the primary factors relevant to training management are administration, resources, curriculum, courseware, scheduling, evaluation, remediation, training reports generation, configuration, and logistics. Students have requirements that interfere with training and a training management system must comply and be able to make decisions for rescheduling. The system must be able to run on a desktop Pentium Level PC and be easily used by instructor/training personnel. Intelligent agent and intelligent programming architectures are at a point of technological maturity today to facilitate their application for this effort. Intelligent decision making for scheduling and tracking has not been accomplished at the team training level but now presents itself as a great opportunity for research in this area.

PHASE I: The end product for Phase I shall be a fully functional, computer-based prototype demonstrating scheduling, tracking, and performance assessment of individual students and students in a team training environment. A technical report of the prototype performance is also required.

PHASE II:The end product of Phase II shall be a fully functional training management system demonstrated in an operational field setting and a technical report documenting all aspects of the system and lessons learned.

PHASE III DUAL USE APPLICATIONS: This type of system has the capability for use in public school systems, industry training, and for all other government and military training requirements. Any of the other services could use this system as it would be a viable training system for C3 regardless of the mission differences.

REFERENCES:
http://www.ott.navy.mil/2_3index.htm
http://www.aims.r.army.mil/

KEYWORDS: Training, Logistics, Scheduling, Intelligence, Collaboration, Administration, Decision-Making, Team Performance, Training Management, Performance Measurement

AF99-098 TITLE: Development of Predictive Model for Rocket Launch Noise Footprint

TECHNOLOGY AREA: Human Systems Interface

OBJECTIVE: Develop a software model of rocket noise useful for evaluating impact on wildlife and communities.

DESCRIPTION: The initiation of spacelift or other rocket vehicle launch programs by the government requires an assessment of the environmental impacts created by the resultant noise under the National Environmental Policy Act (NEPA). This may involve either new or modified vehicles, or new locations/launch conditions. In the past, the noise levels have been estimated by similarity to other vehicles, or by simplified manual calculations involving the rocket engine characteristics. These fail to give a complete two-dimensional noise profile and do not account for the effects of topography or meteorology. The objective of this project is to develop a software model of rocket noise useful to evaluating impact on wildlife and communities. Numerous field measurements of actual launches are available for model validation or for empirical modeling. The model must have the capability of developing quality graphics to depict dBA sound levels or sound levels in different frequency bands, overlaid on local maps.

PHASE I: Initial Phase I activity shall include a complete review of current acoustic generation/propagation technology as applied to rocket engines, and development of a software architecture for modeling. The user interface shall be defined and a demonstration prepared for a limited sample set of conditions.

PHASE II: Phase II activity shall complete the model development in a manner to permit use on any current or defined future rocket system by U.S. or foreign vehicles. Input and output procedures shall be refined for user-friendliness and publishable graphic outputs. A demonstration shall be performed, whereby an upcoming launch will be analyzed, the acoustic footprint predicted, and actual field measurements taken for validation.

PHASE III DUAL USE APPLICATIONS: The effects of launch vehicles acoustics on community acceptance and wildlife is a major concern of the military, commercial ventures and NASA. To broaden the base for commercialization, this model program should be expanded to allow inputs and suitable outputs for turbo jet-propelled aircraft (military and commercial) as well. This would allow for general use in environmental analyses by NASA, FAAA, civil and other land use planning authorities.

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KEYWORDS: Noise, Acoustic, Space Launch, Community Impact, Endangered Species, Two-Dimensional Noise Profile

AF99-099 TITLE: Logistics Technology for Weapon System Support

TECHNOLOGY AREA: Human Systems Interface

OBJECTIVE: Develop technology to improve Air Force sustainment logistics in areas of supportability, deployability, and affordability.

DESCRIPTION: The Air Force requires a flexible, agile, fast-response, and affordable logistics infrastructure to achieve the goals of Agile Combat Support, Lean Logistics, and the Rapid Air Expeditionary Force (explained in the references). Research is needed to develop new techniques and tools for order of magnitude improvements to the acquisition, planning, maintenance, supply, transportation, and deployment of wholesale logistics functional areas, in support of both land and space-based assets. Focus can be on any of the aforementioned functional areas, either singly or in combination. Highly innovative, futuristic concepts will be given much higher consideration than mere incremental improvements to existing capabilities. Emphasis should be placed on technology that improves maintainability, streamlines logistics processes, reduces deployment footprint, and reduces logistics support costs. Examples include automated generation of technical data; advanced materiel/cargo handling equipment; miniaturized, multi-function bare-base facilities equipment; and maintenance/supply of space-based systems. Products may be either hardware or software prototypes, but must be designed so that they can be easily integrated into the Air Force's wholesale logistics environment.

PHASE I: Phase I will result in a final report which documents a requirements analysis, proposed design, projected payoff, commercialization strategy, and a plan for Phase II.

PHASE II:Phase II will result in a prototype technique/tool, a field test to demonstrate the feasibility and payoff, a cost/benefit analysis and associated documentation. The product is a software/hardware tool that improves a specific dimension of logistics support.

PHASE III DUAL USE APPLICATIONS: Commercial development of complex systems should involve the concurrent development of the system's support infrastructure. While deployability may not always be a design consideration in all commercial developments, affordability of the support tail certainly is. Thus the results of this effort would apply to the commercial sector.

REFERENCES:
1. DOD Joint Vision 2010, DTIC Accession Number AD-A311 168 www.dtic.mil/doctrine/jv2010/
2. DOD Logistics Strategic Plan, www.acq.osd.mil/log/mdm/lsp98.htm
3. AF Global Engagement, DTIC Accession Number AD-A318 235, www.xp.hq.af.mil/xpx/21/nuvis.htm

KEYWORDS: Supply, Planning, Logistics, Deployment, Maintenance, Sustainment, Acquisition, Transportation, Life Cycle Costs

AF99-100 TITLE: Impact Injury Modeling Software and Interfacing for the Biodynamic Work Environment

TECHNOLOGY AREA: Human Systems Interface

OBJECTIVE: Development and computer interfacing of biodynamic injury models and criteria for use in the prediction of acceleration impact injury.

DESCRIPTION: Researchers at the Air Force Research Laboratory have performed extensive studies of biodynamic response to impact acceleration. These studies encompass thousands of tests conducted with both human volunteers and instrumented manikins performed over a span of more than 30 years. Results of these studies have been used to enhance the safety of escape system and crash protection design and to provide data for models which are used to predict the potential of injury. Data from these tests include biodynamic accelerations, forces, and displacement time histories, along with subject anthropometry measurements. These data have been integrated into a large in-house data repository which has been named the Biodynamics Data Bank (BDB). The time history files of all tests in the BDB are stored in an MS Excel format, along with tables and queries in an MS Access data base. The BDB will become part of a comprehensive Biodynamics Work Environment (BWE), which has been envisioned to give researchers the capability to easily access all these data and integrate them with biodynamic models in order to quickly solve problems in the areas of human safety and performance.

This topic addresses the need for integrating the BDB with injury models and criteria which can be used to assess the probability of injury during impact acceleration stresses, with particular focus on neck and spinal injury. The injury models can be selected from current or modified models already in use or newly developed ones. They should address the effects of both the duration and magnitude of applied acceleration pulses and/or resulting loads and moments. Equations on which the models are based should be furnished along with information on why the model is appropriate, and references provided if a currently accepted model is employed (e.g. Head Injury Criterion (HIC), Dynamic Response Index (DRI), etc.). The software should be sufficiently flexible to allow the researcher to select the most appropriate injury criteria level for the model (e.g. Mertz, Yamada, etc.), and whenever possible provide the user with multiple probability of injury level curves (e.g., 1 percent, 5 percent , 50 percent, etc.). The software should be able to interface directly with the BDB by allowing the researcher to input acceleration, force, or moment time history or peak data files in MS Excel format. The software should be user-friendly, menu-driven, and written in a common language such as MS Visual Basic.

PHASE I: Should contain a brief description of the proposed models, injury indices, and injury criteria, and a demonstration program which illustrates the use and capabilities of the integration software. It should also contain two or more example models.

PHASE II:Should result in a complete graphical user interface with all of the selected models, injury indices, and injury criteria fully integrated into the software. It should also have features which enable the user to add new models or modify existing ones.

PHASE III DUAL USE APPLICATIONS: This technology will provide information which can be used by civil aviation and automotive safety researchers in the understanding and prediction of neck and spinal injuries incurred during crashes.

REFERENCES: Raddin, J.H., Scott W.R., and Bomar, J.B, et al. Adapting the Advanced Dynamic Anthropomorphic Manikin (ADAM) Technology for Injury Probability Assessment, AL-TR-1992-0062, (AD A252 332), Armstrong Laboratory Wright-Patterson AFB, OH.
KEYWORDS: Database, Neck Injury, Injury Index, Injury Model, Spinal Injury, Human Volunteers, Impact Acceleration, Instrumented Manikins

AF99-101 TITLE: Human Interface Solutions for Emergency Escape System

TECHNOLOGY AREA: Human Systems Interface

OBJECTIVE: Develop innovative technology to increase crewmember comfort/reduce fatigue during extended missions and to protect the crewmember during high-speed ejections.

DESCRIPTION: Ejection seat improvements are sought in three separate areas. These are the development of seat cushions with improved comfort, full crew population accommodation, and ejection compatibility; a full crew population accommodating restraint system with pelvic retraction and commanded haul back capability; and a passive head/neck restraint system for use with existing and future ejection seats. Extended missions in fighter aircraft have made lack of comfort associated with the present Advanced Concept Ejection Seat (ACES) II cushions no longer tolerable. Since these cushions were designed in the 1970's, the automotive industry has made great strides in improving seat comfort. However, the dynamic characteristics of automobile seats are inappropriate for ejection seats where the cushions must not contribute to increased injury during catapult acceleration. A safe, comfortable cushion design must accommodate the full Joint Primary Aircraft Training System (JPATS) pilot population as well. During some flight maneuvers it is possible for the pilot to be lifted out of the seat because the current PCU-15 restraint has little negative G restraint and marginal lateral restraint. Small females are typically even less well restrained. During flight maneuvers when pilots are out of position, they would benefit from an inertia reel, which has a commanded haul back feature to reestablish proper seat contact and flight control interface. Ideally the restraint system should give the pilot freedom to move during flight, e.g. to "check-six" etc., and should provide both upper torso and pelvic retraction to properly position the pilot for safe escape. Full accommodation is a must. Ejection at high speed exposes the crewmember to injurious aerodynamic forces on the head/neck. New helmet-mounted systems make matters worse. A passive head/neck protection system is needed to counteract these aerodynamic forces and allow helmet-mounted systems to provide their considerable performance advantages without compromising safety during ejection.

PHASE I: Develop initial designs and associated analysis to select the most promising approach. Preliminary demonstration of the chosen design is preferred but not required. Document the approach, initial designs and preliminary results (if available) in a final report.

PHASE II:Fabricate and test the final prototype system. Evaluate results and develop a plan for follow-on development. Prepare a final report describing the design along with the test results and recommendations for insertion of the design into applicable Air Force and commercial systems.

PHASE III DUAL USE APPLICATIONS: Since these problems need solution in order to protect and improve comfort, improve safety during ejection, and decrease fatigue during long flights, effective solutions will find a market in both retrofit to existing seats and for inclusion in future ejection seats world-wide. The concepts developed will also find application in the commercial air and automotive industries.

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2. Brinkley, J. W., et al. Evaluation of a Proposed F-4 Ejection Seat Cushion by +GZ Impact Tests, AL/CF-TR-1993-0160, July 1993. (AD A289 700). Wright-Patterson AFB OH.
3. Perry, C. E., Evaluation of a Proposed B-2 Seat Cushion by +Gz Impact. AL/CF-TR-1997-0112, February 1997. (AD A339 408) Wright-Patterson AFB OH.
4. Cass, S., Peck, W., Duncan, Jr., Castiel, H., Crew Escape Technologies (CREST) Mission Area Requirements Study Current and Future Crew Escape Requirements, AL-TR-1992-0183. (AD A269 069). Wright-Patterson AFB OH.

KEYWORDS: Seat Comfort, Inertia Reels, Injury Criteria, Restraint Systems, Commanded Haulback, Aircraft Seat Cushions, Aircrew Safety and Protection, Aerodynamics of Human Head/Neck

AF99-102 TITLE: Advanced Methods for Displaying Large Schematics on Small Screen Devices

TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop an advanced method for presenting large schematics on small screen computer devices.

DESCRIPTION: In the future, aircraft maintainers will be performing all of their maintenance tasks with the aid of a portable computer. The portable computer will be used to present their job assignments, technical instructions, graphics for ordering parts, troubleshooting information and maintenance completion forms. For these computers to be tools that assist the maintainer, they must

be light-weight, portable, and responsive. The small size of the computer facilitates use, but creates new problems in presenting technical information. One of the problems with a portable computer is the size of the display for presenting information. This problem is exaggerated with maintenance tasks due to the requirement for presenting large graphics, schematics, and complex wiring diagrams. The portable maintenance computer must provide the technician with the capability of viewing all of the electronic signal information required to diagnose a fault. In addition, the computer must minimize the requirement for scrolling and zooming on the flight line. The intent is to reduce technician workload, not increase it with demanding graphic presentation requirements. The goal of this effort is to develop an improved presentation concept and not enhanced software graphics applications.

PHASE I: The purpose of this phase will be to define new methods and techniques for presenting large schematics and complex graphics.

PHASE II:A technology demonstration of the methods and techniques established in Phase I will be the product of this phase. In addition, provide specific recommendations for the application of this technology for both DOD and commercial use.

PHASE III DUAL USE APPLICATIONS: The technology developed under this program will have a high commercialization potential, applicable to virtually any maintenance environment in the government and civilian sector.

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4. Wampler, J. L. (1998). Task Filtered Display of Functional Diagrams for Flight Line Maintenance (Technical Report No. (To Be Determined)). Wright Patterson AFB OH: Crew Survivability and Logistics Division, Human Effectiveness Directorate

KEYWORDS: Simplified Schematics, Computerized Wiring Diagrams, Computer-based Electronic Schematics

AF99-103 TITLE: Advanced Audio Interfaces

TECHNOLOGY AREA: Human Systems Interface

OBJECTIVE: Enhance operational Air Force audio command, control, and communications systems.

DESCRIPTION: A requirement exists for effective audio command, control, and communications systems that are based on natural, intuitive interfaces using innovative abilities and requiring no learning or training for efficient operation. The intuitive interfaces facilitate operator task performance, lessen mental and physical workload, reduce fatigue, and improve personnel safety. These intuitive interface technologies include, but are not limited to: 1) auditory system modeling and neural networks for robust signal processing of speech, 2) digital audio technology to allow integration into aircraft systems, 3) noise-induced hearing loss protection, 4) active noise reduction, 5) three-dimensional auditory display for spatial awareness and communications, 6) high-performance noise canceling microphones. Innovation (e.g. auditory system modeling and neural networks) is needed in order for these technologies to be effective in high-noise (in some cases in excess of 140 dB) and high-stress environments characteristic of military operations. This topic represents an opportunity for innovative ideas to be applied to individual components, the integration of multiple components, and the application of these to address current Air Force and DOD deficiencies in audio command, control, and communications and man-machine interfaces. These issues will be even more important in the future within the reduced force structure environment.

PHASE I: Create an innovative interface concept, analyze operator performance and technology feasibility, and produce and deliver a proof-of-concept demonstration, including performance analysis.

PHASE II: Optimize the innovative interface system design, produce, evaluate, and deliver a full-scale prototype of the new interface concept, including full software documentation.

PHASE III DUAL USE APPLICATIONS: Commercial applications of these technologies are possible in the commercial aviation, entertainment, industrial safety, and health care fields, as well as in telemedicine and nuclear facility operation or in any high stress high workload environment.

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Reality Systems: Applications, Research and Development, I(2), pp. 18-26.
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KEYWORDS: Auditory Models, Neural Networks, Noise Reduction, Audio Technology, Speech Recognition, Synthesized Speech, 3-Dimensional Audio, Voice Communications, Human-Machine Interaction

AF99-104 TITLE: Adaptive Eye Protection

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Develop eye protection that adaptively changes to varying levels of brightness to improve human visual performance over a range of light conditions.

DESCRIPTION: Current eye protection against glare produced by optical sources is an inadequate means of personnel protection where precise human motor functions are required for the job such as piloting, factory work, and outdoor activities. This limitation of current eye protection comes from the fact that optical density is flat across all intensities for the given bandwidth, i.e. bright objects become dimmer but dim objects become undetectable. Safety is compromised by the reduction of visual and situational awareness caused by conventional eye protection. This project will investigate, build and test new technologies to allow adaptive response to varying intensities within a given scene. The new eyewear will be capable of strong reduction of intense objects while allowing dim objects to pass through with little or no attenuation.

PHASE I: The first phase of this effort will be to identify mechanism(s) that support the adaptive eye protection. Phase I will produce a final report describing the physics of the technique and a proposed design for the eye protection. A laboratory demonstration of the technique is required.

PHASE II:Phase II will refine the proposed design from Phase I and build a prototype of the eye protection. Laboratory testing will be conducted on the prototype to demonstrate the adaptive nature of glare reduction. Phase II will include a prototype version of eyewear, lab report of glare reduction tests, and identification of proposed design modifications/improvements for full-scale production.

PHASE III DUAL USE APPLICATIONS: Adaptive glare eye protection has significant commercial applications, especially where intense light and laser light are used. For example, reducing glare to pilots due to the sun and outdoor laser shows not only increases pilot effectiveness, but also increases passenger safety as well. Any outdoor activity can benefit from an adaptive glare reduction over conventional sunglasses since visual acuity will be improved. The ski apparel market is a promising opportunity.

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KEYWORDS: Adaptive, Eye Protection, Glare Reduction, Laser Eye Protection

AF99-107 TITLE: Innovative Information Technologies

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop innovative information technologies for enhancing the performance, availability, and affordability of C4I systems and subsystems.

DESCRIPTION: Proposals may address any aspect of Information pervasive technologies not specifically covered by other SBIR topics. Areas of interest include, but are not limited to, innovative concepts and technologies in: Global Awareness, Dynamic Planning and Execution, and Global Information Exchange.

- Global Awareness: Global Awareness entails the affordable operational capability, from local to global level, for all pertinent

personnel to understand militarily relevant situations on a consistent basis with the precision needed to accomplish the mission. This understanding is achieved by: exploiting information from Intelligence, Surveillance and Reconnaissance sensor data; examining open source and commercial data, including data provided by other government agencies, that is required for the entire spectrum of military operations. The information is then fused to support Dynamic Planning and Execution, via the Global Information Exchange distribution system. The knowledge, information and data will then be archived in the Global Information Base for continued use and historical analysis. The technologies required to achieve this capability in an affordable military system, including appropriate access mechanisms for our coalition partners, will be developed and transitioned under this thrust.

- Information Exploitation
  - Image/Video/Text
  - Signals
- Information Fusion
  - Algorithms
  - Multi-Sensor Collaboration
- Global Information Base
  - Management and Control
  - Active Information Systems
  - Precision Distribution

- Dynamic Planning and Execution: This thrust concentrates on the aerospace commanderís ability to rapidly acquire and exploit superior, consistent knowledge of the battlespace, through a worldwide distributed decision-making infrastructure of virtual battlestaffs and intelligent information specialists.

- Next Generation C2
  - Configurable Aerospace Command Center
  - Time Critical C2
  - Real-Time Sensor-to-Shooter Operations
  - Targeting
- Joint/Combined Coalition C2
- Collaboration/Simulation/Visualization
- Aerospace Integration

- Global Information Exchange: Global Information Exchange is the ability to interconnect all members of the Air Force via a netted communication and information system, available anywhere, at any time, and for any task or mission. The ability to communicate by moving raw and processed information throughout a global communications grid is fundamental to Command and Control. Inherent in this capability is the idea of universal information availability across different transmission media with different characteristics. The Air Force's information network must have global reach for its normal day-to-day operations as well as the capability to allow an instant surge of connectivity and capacity into a localized theater for mobile and fixed-site users.

- Global Communications
  - Multiband/Multifunction Communication
  - Robust Tactical/Mobile/Wireless Networks
  - RF Communications Systems
- Defensive Information Warfare
  - Information Systems Protection
  - Attack Detection
  - Computer Forensics
  - Secure Computing
- Information Systems and Networking
  - Distributed/Adaptive/Mobile Computing
  - Adaptive Systems
  - Survivable Systems
  - System Architecture
  - Design and Evolution

PHASE I: Provide a report describing the proposed concept in detail and show its viability and feasibility.

PHASE II:Fabricate and demonstrate a prototype device, subsystem, or software program.

PHASE III DUAL USE APPLICATIONS: Many Information Technologies have substantial dual-use potential and will impact competitiveness and performance of the commercial sector as well as the military sector. All solutions proposed must have potential for use/application in the commercial as well as military sector, and potential commercial applications must be discussed in the proposal.

KEYWORDS: Computers, Intelligence, Communications, Global Awareness, Command and Control, Information Technology, Global Information Exchange, Dynamic Planning and Execution

AF99-108 TITLE: Threat Prediction Fusion

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Development of innovative approaches to data fusion that support the threat prediction.

DESCRIPTION: Data Fusion has been defined (Joint Directors of Laboratories (JDL), Technology Panel on C3 (TPC3), Data Fusion SubPanel (DFSP)) as: "Information processing that deals with the association, correlation, and combination of data and information from single and multiple sources to achieve refined position and identity estimation, complete and timely assessments of situations and threats, and their significance in the context of mission operation. The process is characterized by continuous refinement of its estimates and assessments, and by evaluation of the need for additional sources, or modification of the process itself, to achieve improved results." There are four current functional levels of data fusion: Object Refinement, Situation Refinement, Threat Refinement, and Process Refinement. This SBIR addresses Level-3, Threat Refinement data fusion functionality.

The JDL DFSP has defined Level-3 processing as: Level-3, Threat Refinement develops a threat oriented perspective of the data to estimate enemy capabilities, identify threat opportunities, estimate enemy intent, and determine levels of danger. Key functions include: (1) capability estimation, (2) predict enemy intent, (3) identify threat opportunities, (4) offensive/defensive analysis, and (5) multi-perspective assessment. Current data fusion techniques that support Threat Refinement are very limited. Theoretical solutions exist that support prediction of kinematic data (e.g., tracking), which basically is predicting the next location of an object (i.e., where it is), but very little work has addressed the more abstract requirement of why is it there, and for what reason is it there. It is the answer to these more abstract questions that is the focus of this topical area, which will address innovative approaches to data fusion that support the threat refinement area, with an emphasis on the threat prediction capabilities.

PHASE I: Phase I will investigate innovative approaches to data fusion that support the threat refinement area, with an emphasis on the threat prediction capabilities. Phase I will result in a detailed plan and prototype software, which demonstrates the feasibility of a potential Phase II effort.

PHASE II:Phase II will design and develop the innovative approaches to data fusion that support the threat refinement area, with an emphasis on the threat prediction capabilities as recommended in Phase I, and then prototype a subset of the design to demonstrate the threat prediction capability.

PHASE III DUAL USE APPLICATIONS: Phase III will fully implement and demonstrate the innovative approaches to data fusion that support the threat refinement area, with an emphasis on the threat prediction capabilities, as recommended in Phase II prototype. This topical area has dual-use potential wherever data from different (or even similar) sources are required for decision making, especially when the impact of the current situation needs to be addressed. Examples of potential industries include: drug enforcement and drug interdiction.

KEYWORDS: Data Fusion, Sensor Fusion, Threat Prediction, Threat Refinement

AF99-109 TITLE: Measures of Effectiveness for Abstract Data Fusion

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Development of innovative measures of effectiveness for high level data fusion.

DESCRIPTION: Data Fusion has been defined (Joint Directors of Laboratories (JDL), Technology Panel on C3 (TPC3), Data Fusion SubPanel (DFSP)) as: "Information processing that deals with the association, correlation, and combination of data and information from single and multiple sources to achieve refined position and identity estimation, complete and timely assessments of situations and threats, and their significance in the context of mission operation. The process is characterized by continuous refinement of its estimates and assessments, and by evaluation of the need for additional sources, or modification of the process itself, to achieve improved results." Current data fusion techniques beyond Level-1(correlation) are mainly manual and cannot keep pace with the highly mobile, dynamic forces likely to be faced in the future. New approaches to data fusion levels (2,3, and 4) are being developed/implemented, but there is an obvious lack of metrics available to evaluate the effectiveness of these more abstract data fusion levels, even though a plethora of metrics exist to support Level-1 data fusion. This topical area will address innovative measures of effectiveness to support the evaluation of Levels 2,3, and 4 data fusion.

PHASE I: Phase I will investigate innovative measures of effectiveness that can be utilized to support higher levels of data fusion. Phase I will result in a detailed plan and prototype software, which demonstrates the feasibility of a potential Phase II effort.

PHASE II:Phase II will design and develop the innovative measures of effectiveness which can be utilized to support higher levels of data fusion as recommended in Phase I, and then prototype a subset of the design to demonstrate the validity of the measures of effectiveness.

PHASE III DUAL USE APPLICATIONS: Phase III will fully implement and demonstrate the innovative measures of effectiveness which can be utilized to support higher levels of data fusion, as recommended in Phase II prototype. This topical area has dual-use potential wherever data from different (or even similar) sources are required for decision making, especially when multiple solutions need to be evaluated. Examples of potential industries include: drug enforcement and drug interdiction.

KEYWORDS: Data Fusion, Sensor Fusion, Measures of Merit (MOM), Measures of Performance (MOP), Measures of Effectiveness (MOE)

AF99-110 TITLE: High Throughput Volumetric Memories

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Identify and characterize candidate media, optoelectronic system architectures, or other write/read concepts to provide storage capacities of at least 1 Terabit/cm3 (or at least 30 Gigabit/cm2) and throughput rates of a Gigabit per second. In addition, to identify and characterize hardware and software to perform advanced database management tasks such as associative retrieval for data correlation and fusion, as well as allow successful integration of various volumetric memories into single and multiprocessor network architectures.

DESCRIPTION: The advent of optoelectronic computing and highly parallel electronic processing necessitates storage systems with enormous capacity and bandwidth. Meeting this demand with current technologies results in storage systems that dominate processors in terms of overall cost, power consumption, volume and weight. Recognizing these and other problems inherent to high data rate, high density data storage and associative retrieval, the Air Force Research Lab Information Directorate is investigating erasable optical disk and multi-dimensional volumetric memory technologies. These technologies offer great promise due to their high data densities and their inherent parallelism in recording and readout, but in order to take full advantage of this, data transport systems must be designed to successfully integrate these mass storage systems with existing computer networks, with minimal data bottlenecking and latency.

This effort seeks to exploit the recent advances made in the field of nano-technology in order to increase bit storage density to at least 1 Tb/cm3. Organic polymers, synthetic DNA, and covalent transition metal compounds all have shown the potential to increase storage densities by orders of magnitude. The challenge is to fabricate them on a nano-scale and then address (write/read) them at room temperature. It is projected that these systems will yield aggregate data rates on the order of 1-10 Gb/s.

These extremely high bit densities and data rates however, necessitate a totally innovative search paradigm for accurately minimizing latency times. The development of associative retrieval algorithms will insure that data is transported within a cognitive bandwidth, i.e., minimum information needed to identify and/or understand data.

Another area of growing interest involves optimally utilizing these inherently parallel memories in traditional serial network scenarios. This should be done in a way that maximizes the net throughput rate to all users, while minimizing system complexity. The problem can be broken up into three different areas. First, hardware issues are of great interest. Traditional electronic transmission lines may not work well at these data rates. Fiber optics have shown a lot of promise in this area, as shown by the newly designed HIPPI-6400 standards. Additionally, modulators and detectors designed to allow one to one imaging would simplify the optical design of memory systems. Free space optics may be a long term solution as well, not only for their very high data bandwidth, but also since they can be used for parallel processing applications. Second, software issues become critical in terms of manipulating these large pages of data. Tied closely to this are data protocol issues. This includes optimizing the parallel-to-serial conversion to minimize data bottlenecking, finding the optimal block size to perform error corrections, selecting optimal page sizes, etc.

PHASE I: Consists of concept definition with experimentation adequate for feasibility demonstration.

PHASE II: Would consist of the design, fabrication, and testing of a brassboard.

PHASE III DUAL USE APPLICATIONS: Would involve the generation and implementation of marketing plans for commercializing the technology developed under Phase I and II. High density mass storage would impact every business from entertainment to medicine. Imagine 4000 hours of audio, or all the X-Ray films of a large metropolitan hospital, stored on a device the size of a sugar cube. The development of this technology would benefit users from the Library of Congress to the records department of insurance companies.

KEYWORDS: Fiber Optics, Nanotechnology, Organic Polymers, Volumetric Memories, Associative Retrieval, Page Oriented Memories, Spatial Light Modulators

AF99-111 TITLE: Computer Forensics

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Development of computer analytic techniques and a forensics toolkit for use by computer forensics examiners. This work will focus on development of technology for the detailed evaluation and in-depth analysis of data related to computer crime, unauthorized computer use, and military and industrial espionage activity.

DESCRIPTION: Classically, computer forensics is a narrowly defined technology area focusing solely on the process of evidence extraction from computer media that has been seized by law enforcement authorities as part of an investigation into illegal or criminal activities. We, however, view computer forensics as encompassing a broader area of technology which includes processes from both the Detect and React paradigms of the broader information assurance technology area. In that context, computer forensics is an emerging technology that is concerned with a continuum of activities spanning the spectrum from the collection of audit and intrusion data to classic evidence reconstruction for legal purposes. Forensics, therefore, includes intrusion detection data gathering, assessing damage resulting from information attacks, locating hidden and disguised files, and data recovery from malicious (as opposed to) inadvertent destructive activity. In addition to the traditional tools used by computer forensics examiners, other tools such as intrusion-detection tools, computer auditing tools, and network management tools provide additional relevant evidence and information.

A purely military application for this technology could be automated rapid exploitation of data contained in adversary computers seized during swift military operations. The work will address the reconstruction of evidence from computers where the data/files have been intentionally or maliciously destroyed or modified for the purpose of concealing an illegal activity. Other conditions under which forensics tools could provide assistance are detection of modified system binaries, identification of malicious programs, discovering indications of sniffer activity on a specific system, and identification of various foul play indicators such as modified system logs and "backdoors". Technologies sought under this program include: techniques for handling password-protected files; methods for locating and decrypting of encrypted files; procedures for uncovering data hidden within seemingly innocuous data (steganography); tools for searching for hidden and disguised files, file filters for reducing both the search space and time for forensics investigation of large media; tools for maintaining the integrity of the forensics process while managing the forensics workflow. All of these tools should be interoperable and accessible through a common user-friendly interface.

PHASE I: Develop and prototype techniques that address existing deficiencies in computer forensics. Specific technology areas to be investigated include: rapid discovery of evidentiary information, decryption, steganography identification and recovery, password protected file discovery and bypass, data integration from various evidentiary sources, and verifiable forensics workflow management. The products of this phase should be a system architecture and/or proof of concept demonstrations.

PHASE II:Build and test the system architecture specified in Phase I.

PHASE III DUAL USE APPLICATIONS: The Air Force needs computer forensics technology in order to maintain its complex, large-scale information systems and networks in a continuous operational state. Also, the Air Force requires this technology to provide automated support for the damage assessment data recovery functions which are invoked as a result of successful penetrations by adversaries. As a result of the current movement to electronic commerce environments, (i.e., the Internet, World Wide Web and corporate Intranets) the business and industrial sectors require strong and reliable computer forensics technology to mitigate the effects of the increased exposure and vulnerability of their information assets to malicious attack from the outside as well as misuse by disgruntled insiders. The commercial sector needs this technology to maintain customer confidence in the integrity of its transactions and financial data.

REFERENCES:
1. Clark, F. et. al., "Investigating Computer Crime (CRC Series in Practical Aspects of Criminal and Forensic Investigations)"
2. Icove D. et. al., "Computer Crime: A Crimefighter's Handbook"

KEYWORDS: Auditing, Computer Forensics, Information Systems, Intrusion Detection

AF99-112 TITLE: Communication Performance Measurement for the Mobile User

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop an affordable product for system-independent mobile Information Technology (IT) performance measurement.

DESCRIPTION: Mobile users of high-frequency (HF) radio and Satellite service are at a disadvantage due to limited access bandwidth to packet services such as the Internet. An efficient mobile capability, independent of the IT system providing

communication services, is required to measure user-oriented performance. Parameter measurement is required to establish a performance baseline and to provide an input to an independent audit log for service record of packet delays and data transfer service losses for mobile nodes. Time stamp logging at the critical mobile end-user interface is required for determination of network throughput and latency. Timestamp consistency is typically provided by using global positioning system (GPS)-based Network Time Protocol (NTP) but accuracy of current timestamps is marginal. In theory, unidirectional delays can be measured accurately using the global positioning system (GPS) receivers but this can be expensive. Therefore, innovation in developing compact, lightweight and accurate timestamping techniques is required. This capability will also be useful in the validation/verification of simulation results and in validation of digital telecommunication services quality of service (QoS) data.

PHASE I: Design and demonstrate the feasibility of a low-cost unidirectional measurement capability.

PHASE II:Fabricate a mobile measurement product based on the techniques developed in Phase I. Demonstrate the effectiveness of these techniques.

PHASE III DUAL USE APPLICATIONS: This technology is widely applicable to both military and commercial mobile information technology systems. An affordable tool for the measurement of mobile IT performance would be used both by independent cellular providers as well as by developers and integrators of military mobile wireless communications systems.

REFERENCES:

1. T.J. Kostas et al., ìReal-Time Voice Over Packet-Switched Networksî, IEEE Network Mag., January/February 1998
2. D.L. Mills, ìNetwork Time Protocol (Version 3), Specification, Implementation and Analysisî, RFC 1305, March 1992

KEYWORDS: User-Oriented, Mobile Communications, Performance Measurement

AF99-113 TITLE: Internet Protocol (IP) over Asynchronous Transfer Mode (ATM) through Narrowband Common Data Link (CDL)

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Investigate technologies and techniques required to perform standard IP-based inter-networking through a CDL narrowband link. This includes the design of protocols for implementing IP-based services (FTP, TCP, UDP) through the user channels of reconnaissance data links such as the Common Data Link (CDL) narrowband link.

DESCRIPTION: Initially, the relevance and application of existing RFCs as related to the implementation of CDL and the use of IP over synchronous error-prone links, including Reliable Multicasting Datagram Protocol (RMDP) and IP over ATM (RFC 1577). Research would then be conducted to collect performance data to determine the most suitable implementation parameters for the link. Emerging network technologies would also be thoroughly evaluated to determine the optimum implementation for CDL (ATM, Fast Ethernet, Gigabit Ethernet or IEEE 1394/Firewire). Different physical networks could be used on the airborne and the surface systems, i.e., ATM on the platform and Fast Ethernet on the ground. Large cost savings could be realized due to the commodity nature of these COTS products. In addition, a standardized interface will allow commercial network users to include the asymmetric multiplexing capabilities of this system into their commercial products (computers, routers, switches, etc).

PHASE I: Investigate the use of RFCs for application in CDL data links. Research the performance to determine the most suitable implementation parameters for the data link. Evaluate the related emerging technologies for application to data links such as CDL.

PHASE II:Develop software for a CDL Multiplexer/Demultiplexer (MDM) to enable IP-based communication through the MDM. Integrate commercial ATM interfaces into a CDL system. Implement Microsoft Peer Web Services (a web server) in the airborne platform as a means for delivering telemetry status to the ground user, receiving commands from the ground, and providing situational awareness to a terrestrial C3I network. Distribute video data directly to the terrestrial network from the platform using broadcast UDP. Develop a CDL-Internet Gateway, which will allow a CDL user to access the civilian Internet. Demonstrate the application of the CDL-Internet Gateway capabilities by having a simulated platform pilot (of a Guardrail) access the civilian Internet to obtain a weather update and to buy a book on landing a plane. Develop software to allow existing CDL data link terminals to demonstrate asymmetric (200 kbps/10.71Mbps) and symmetric (10.71Mbps) Line-of-Sight (LOS) Virtual LAN service to connect geographically diverse C3I LANs via LOS links. Develop software and hardware to improve LOS to a 45 Mbps symmetric link with Reed Solomon forward error correction coding. Develop capability for LOS Virtual LAN service through a Ku-band satellite link by demonstrating ability to provide forward and return link at reduced bit rates compatible with current commercial satellite transponders.

PHASE III DUAL USE APPLICATIONS: The technologies developed would allow the communications between and among diverse data terminals with minimal interface adjustment considerations.

KEYWORDS: Ethernet, Internet Protocol, Local Area Network, Asynchronous Transfer Mode

AF99-114 TITLE: Distributed Collaborative Modeling and Simulation

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop and demonstrate collaborative simulation, analysis, and visualization technologies to support a distributed engineering environment.

DESCRIPTION: The contractor shall research, develop and demonstrate innovative constructive and virtual simulation technologies that support the overall concepts of the collaborative engineering environment and distributed simulation networking. Maximum use of commercial-off-the-shelf desktop, workstations, and distributed simulation technologies shall be employed to provide a virtual engineering development environment so that integrated information concepts can be evaluated in a realistic operational combat-like environment. Research from this effort shall play a critical role in the rapid cost effective development of weapon systems. Technologies developed shall provide characterizations, performance data, life-cycle cost information to assess mission benefits, generate designs and implementations, and/or generate Cost of Function and Measure of Effectiveness estimates. The following technical areas are of major concern:

a. Off-board and on-board sensor modeling
b. Data collection and analysis, and configuration control
c. Standard Query Language (SQL) compatible data base management system product/process models
d. Visualization of simulation scene, mission profile, simulation parameters and weapon system performance
e. Distributed simulation networking concepts
f. Affordability and cost modeling

PHASE I: The desired products of Phase I are 1) identification of the enabling realtime or non-realtime technologies for modeling and simulation, 2) conduct of specific experiments to verify critical aspects of the defined concepts, 3) development of a system specification, implementation approach, and demonstration plan. The contractor shall also document the potential for a Phase II follow-on effort.

PHASE II: Accomplish a detailed design, develop the prototype technology and demonstrate the proposed technology in the appropriate Information Directorate simulation facility. The contractor shall also detail his plan for his Phase III effort.

PHASE III DUAL USE APPLICATIONS: The desired product of Phase III is a robust M&S capability for use in defense and commercial information and sensor technology development. M&S is an enabling technology and a change in the way of doing business that will have major implications for the commercial and defense sector. The commercial marketplace is presently making greater use of generic simulation techniques, simulation infrastructure, and off-the-shelf components for applications in financial industries, manufacturing, industrial process control, biotechnology, healthcare, communication and information systems. The aircraft and automotive industries have demonstrated the success of integrated computer assisted design with supporting modeling and simulation to bring products to market quickly. Advances in software and computer technology are making virtual prototyping possible and affordable for the small to medium business. Software development itself is a manpower intensive endeavor. Requirements definition remains a problem area where the user is unable to verbalize what he/she wants in detail. Virtual prototyping of software requirements and modeling of the software is a future growth area in which simulation is used to review completeness of software requirements and functionality.

KEYWORDS: Data Analysis, Data Collection, Realtime Simulation, Modeling and Simulation, High Level Architecture, Collaborative Engineering, Collaborative Virtual Prototyping, Distributed Interactive Simulation

AF99-115 TITLE: Multiple Simultaneous User Interface Technologies For C4I Systems

TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop multiple simultaneous human-computer interfaces (HCI) utilizing non-standard computer input devices.

DESCRIPTION: The increasingly complex battlefield environment drives the requirement for the presentation and interactive control of the endless stream of information arriving from a combination of sensors deployed on a variety of platforms. The military commander and his staff are provided an enormous amount of information to interact with and disseminate. Today's command center consists of a commander directing multiple operators who have one-to-one interaction with the information processing software, either at individual workstations or collectively on large screen displays.

The display and manipulation of real-time multimedia data in a battlefield operations control center requires multiple user

interaction, i.e. more than one operator needs access to a variety of information processing software at any given time. The interaction must be real-time to support critical decision-making time frames of the military commander.

Current computer systems are limited to a single input device (standard mouse and/or keyboard) controlled by a single operator. Alternative input devices such as voice recognition software and laser pen/pointer devices suffer the same limitations as the traditional keyboard/mouse combination. The need to allow multiple operators to simultaneously interact with a large high-resolution display hosting information processing/presentation software via non-traditional input devices is the main objective of this effort. All solutions must be DII COE compliant and based on COTS products, either commercially available within one year or under development for near term product release (under two years).

PHASE I: Identify current limitations of HCI technology and input devices that prevent multiple simultaneous use of the traditional keyboard/mouse and speech/laser pen input devices. Research and identify actual innovative techniques to overcome the single user/single input device, using commercial and university research and development programs as the subject of the study. Provide recommendations, alternatives, and a feasibility demonstration of candidate technologies. All technology candidates should have minimized cost and physical dimensions and be DII COE compliant.

PHASE II: Phase II shall accomplish a prototype development and/or demonstration of multiple simultaneous HCIs utilizing traditional keyboard/mouse and speech/laser pen input devices.

PHASE III DUAL USE APPLICATIONS: The capability to have simultaneous control of computer software applications by multiple users will allow for interactions never before possible. It could be useful in air traffic control, medical training and classroom distance learning where multiple user access to the same data or display is required.

KEYWORDS: Human-Computer Interfaces, Multimedia Data Display and Control, Non-Traditional Computer Input Technologies

AF99-116 TITLE: Mixed-Resolution Modeling of Command and Control

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop techniques for modeling command and control scenarios composed of entities at various levels of detail/complexity.

DESCRIPTION: Assessment of the combat worthiness of C4ISR techniques, equipment and doctrine involves the construction of large-scale simulations, often comprised of components that vary widely in scope and/or complexity. Traditional synthesis efforts have taken a "locate and integrate" approach, whereby disparate models are coupled (for example, the outputs of a more detailed model are often passed as performance measures to broader-scope simulations) with little thought as to whether or not these couplings are "valid." There is much research required to validate -- or invalidate -- these traditional approaches (e.g., Lanchester Equations), and to set the stage for appropriate (i.e., logically/physically valid) reuse of legacy models and data.

PHASE I: Perform preliminary investigations of JSIMS, JWARS, NASM, Next Generation Mission Model (NGMM) and EADSIM as they relate to Mixed-Resolution Modeling and model/data interoperability. Develop an approach for improved MRM modeling, both in a general sense and in specific detail, for one of the above listed systems.

PHASE II: Accomplish a detailed design, develop a prototype mixed-resolution modeling formalism, and demonstrate the proposed technology in the appropriate Information Directorate simulation facility. The contractor shall also detail his plan for his Phase III effort.

PHASE III DUAL USE APPLICATIONS: The desired product of Phase III is an advanced technology demonstration of the worthiness of MRM techniques in complex combat simulations. Great opportunities exist for combining the benefits of formal theory and computational experimentation towards increasing realism in large scale simulation; in any domain.

KEYWORDS: JWARS, Aggregation, Model Abstraction, Command and Control, Lanchester Equations, Mixed Resolution Modeling, Variable Resolution Modeling

AF99-117 TITLE: Time Critical Command and Control (C2)

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop and demonstrate a new generation of technologies and tools for situation analysis, planning, resource allocation and execution monitoring in near real time.

DESCRIPTION: Develop and demonstrate a new generation of situation analysis, planning, resource allocation, and execution

monitoring technology that will enable in-time engagement of critical targets across a spectrum of time-critical missions from time-phased attack of fixed (e.g. factory) and moving (e.g. tank column) targets, to the real-time use of hunter-controller-killer assets against short exposure time targets (e.g. transporter-erector-launcher). Central to this program is a core of technology developments that will enable a rapid, proactive, interleaved planning and execution monitoring capability with an emphasis to reduce the time to provide dynamic, distributed, continuous, planning, assessment and re-planning capabilities linking Campaign, Force, Mission and Engagement echelons C2 operations. Also needed is the capability to skip echelon, e.g. Campaign level to a "shooter" or "mover" at Engagement level, while informing elements at the Mission and Force echelon levels. In developing a theater air campaign plan for future regional conflicts, a planning staff will need to take into consideration the influences of other members of the coalition force. The influences include differing Rules Of Engagement (ROE), "offensive" assignments, differing military subordination, and authority roles. What is needed is a planning system that is designed for use with coalition forces. Such a system should be adaptable to differing coalition force structures. Mixed-initiative planning should include the capability to transcend language and cultural barriers. The response to future crisis will need to occur more rapidly than ever before. Part of this response will include planning by a commander and his/her staff while en route to a theater of operations. This requires a planning capability that is extremely portable, yet powerful enough to take advantage of multiple knowledge and data sources while in flight. Such a system, for example, a lightweight, portable COTS based solution that implements a knowledge based planning system that can be used in an airborne environment for rapid crisis response supporting multi-national coalition forces, is required to analyze information to determine strategies, collaborate with both forward and rear Air Operations Centers (AOC), and build/modify plans in response to events in the environment. This effort should provide the United States the capability to project sufficient power rapidly, seize the initiative in the early stages of a major conflict. Provide commanders with rapid, responsive and reliable options to deter conflict or make the difference between a quick, efficient victory and a protracted, costly engagement.

PHASE I: Perform preliminary investigation into technologies and tools that are capable of meeting the objective of this effort. The solution should use standards-based, commercial-off-the shelf (COTS), Geographic Information System (GIS) and client/server software (i.e. Web server and browser) and be capable of supporting the entire spectrum of operations. Cost, benefit, risk, portability for use en route to a theater and other related technical concerns shall be addressed.

PHASE II:Develop and demonstrate the prototype tool(s) or technologies on a feasible scenario appropriate for both military and commercial applications. For example, real-time route planning for Air Force aircraft during conflict and commercial package carriers (e.g. Fed Ex). Metrics such as time to complete task, completeness of the result, level of uncertainty and others shall be documented showing increased capability over existing systems and capabilities.

PHASE III DUAL USE APPLICATIONS: Information-Intensive interactions between computational nodes on the network is defined as network-centric operations. Whether these interactions are focused on commerce, education, or military operations, there is "value" that is derived from the content, quality, and timeliness of information moving between nodes on the network. This value increases as information moves toward 100% relevant content, 100% accuracy, and zero time delay toward information superiority. Tools and technologies developed by this effort will have significant impact on industry as well as the military.

KEYWORDS: Real Time, Uncertainty, Coalition Forces, En-Route Planning, Rules Of Engagement, Execution Monitoring, Knowledge Based Planning, Knowledge Based Software

AF99-119 TITLE: Tools and Techniques for Advanced Knowledge Discovery

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop a new generation of Knowledge Discovery and Data Mining tools for intelligent, automated data/knowledge discovery. It is envisioned that an advanced Knowledge Discovery system could draw upon algorithms, methods, and techniques from a number of fields including (but not limited to) machine learning, pattern recognition, knowledge acquisition/extraction, artificial intelligence, databases (data warehousing) and statistics.

DESCRIPTION: The capability to collect and store data has far outpaced our capabilities to make use of that data. While efficient storage and lookup tools abound, the ability to analyze and interpret these large bodies of data/knowledge is still lacking. A new generation of tools and techniques to automatically and intelligently assist humans in finding useful knowledge from this data is needed. For the purposes of this solicitation, knowledge discovery is referred to as the OVERALL process of discovering useful knowledge from data. This process will include steps for data selection/sampling, preprocessing, transformation, data mining, postprocessing, and interpretation/evaluation of the discovered patterns into knowledge. The Data Mining step, applying algorithms to extract patterns from data, is an important step in the knowledge discovery process. While proposals for advanced data mining techniques will be considered, those focusing more on other portions of the overall Knowledge Discovery process will be given preference. Much has been done (and is being done) commercially in the area of data mining and should be leveraged to the greatest extent possible.

PHASE I: Identify, investigate, and prototype an advanced knowledge discovery capability and identify potential Air Force

and commercial users of these products.

PHASE II:Develop and demonstrate a unique large-scale knowledge discovery capability in both Air Force and commercial domains.

PHASE III DUAL USE APPLICATIONS: This technology could have a major impact on any military or commercial application that could benefit from intelligent analysis and interpretation of large amounts of data. Some of these include: sales, health care, fraud detection, astronomy, biology, weather, nuclear power plant control, decision support systems, and military command and control.

REFERENCES:
1. Usama M. Fayyad, Gregory Piatetsky-Shapiro, Padhaic Smyth, and Ramasamy Uthurusamy, Advances in Knowledge Discovery and Data Mining, Published by the AAAI Press / The MIT Press, ISBN 0-262-56097-6, 1996.
2. W. Frawley and G. Piatetsky-Shapiro and C. Matheus, Knowledge Discovery in Databases: An Overview. AI Magazine, Fall 1992.

KEYWORDS: Databases, Data Mining, Machine Learning, Pattern Recognition, Artificial Intelligence, Knowledge Acquisition/Extraction

AF99-121 TITLE: Intrusion Detection And Monitoring Of Large-Scale Networks

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop a real-time common operating picture of the information infrastructure that enables timely response to network faults, IW attacks, and will decrease the manpower and expertise required.

DESCRIPTION: The advent of broadband communications deployed with fiber, wireless, fixed and mobile assets has enabled the establishment of decentralized and distributed information systems that support large numbers of users simultaneously. It is critical that a common operating picture of the information infrastructure be developed that addresses both the health and security posture of the network. This common operating picture will provide commanders a readiness indicator of communication, network, and computer resources that are required to carry out todayís Intelligence, Planning, Execution, Assessment, and Logistics functions. The fused picture of the information battle space will also permit early Indications and Warnings (I&W) of imminent Information Warfare (IW) attacks, and a coordinated assessment and containment of the attack afterwards. These capabilities will be realized by the fusion of network management information to hierarchical or centralized organizations to achieve real-time network management and control simultaneously for Unclassified, Secret, NATO/Coalition, and Top Secret (with compartments). This will be accomplished through the use of standards-based management platforms, intrusion detection systems, and high-assurance network boundary devices such as guards, firewalls, and secure object brokers.

PHASE I: Investigate resource allocation and apportionment mechanisms to control execution of tasks in an object oriented distributed computing system. Investigate and identify multi-level Network Management Systems mechanisms that operate in a cooperative manner to provide hierarchical, peer-to-peer, summary level, and component level network management across multiple user domains. Mechanisms should consider available information system resources (processing, storage), available communication network resources (bandwidth) and user requirements (deadlines, level of effort, scope, security, etc.).

PHASE II:Construct monitoring and management mechanisms at the information system and communication network layers that interpret the current environment state and execute changes to the information system and network to accommodate given user tasks and requirements.

PHASE III DUAL USE APPLICATIONS: The developed mechanisms will provide monitoring and management for Distributed Information Infrastructure(s) and provide a common operating picture, with reduced manning and logistics for deployed military Command and Control resources. This technology also has broad application to the telephony and data communications industries who provide information system and communication network services.

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KEYWORDS: Network Management, Information Systems, Distributed Systems

AF99-122 TITLE: Dynamic Data Intensive Intelligent Technology

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop adaptive data intensive techniques that are capable of dynamically manipulating, filtering, aggregating, and managing large amounts of data according to specific usage/function, in commodity form/blocks, for rapid integrated access to large amounts of multiple information sources dynamically structured using intelligent (re)configurable memory management techniques.

DESCRIPTION: The approach will be development of techniques to export information about data structures and access patterns from a database. Intelligence "wandering through memory" will lead to very large information stores organized around thousands of DRAM chips which will dynamically (re)configure according to function. Techniques such as data aggregation/dissemination, prefetching data, restructuring data based on locality and rapid fetching of data from main memory will be used to configure dynamic data/knowledge processing. Adaptive memory techniques in conjunction with advanced data structures could provide innovative ways to both access and store various forms of data/knowledge. In the past data repositories (databases) were viewed as static stores of information that had to be identified, retrieved, and sent to a central analysis process. The data intensive paradigm is that the data stays in place, and the analysis processes come to the data. Techniques are needed to provide ways data should be dynamically structured and stored for efficient retrieval as well as provide adaptable transformation techniques to structure knowledge which can be managed more efficiently so that information can be automatically filtered, manipulated and summarized. The ability to efficiently develop such configurable intelligent data systems relies significantly on the development of new concepts for transforming functions into dynamic processes that automate and improve how to integrate and analyze information, make decisions under uncertainty and communicate knowledge. The result will dramatically improve data access capability within computing environments and perform situation analysis of relevant data and/or information/knowledge. Experiments will be designed to demonstrate the relevance of the technology to Global Awareness as recommended by New World Vistas. These experiments will also enable measurement, comparison and evaluation of competing designs to support joint data intensive efforts of DARPA and the Infomation Directorate of the Air Force Research Laboratory.

Mechanisms to be investigated include (1) intelligent information technology using (re)configurable logic blocks/chips, (2) adaptable memory design/configurations, (3) electro/optical special purpose architecture enhancements, (4) dynamic intelligent special purpose function architectures and (5) evolvable data/knowledge base configurations for scaleable information aggregation/processing. Technical challenges include unique use of adaptive architectures, dynamic databases, and information integration.

PHASE I: Will investigate development of techniques for designing, developing and integrating large-scale dynamic data intensive information systems

PHASE II:Will demonstrate a dynamic adaptable data/knowledge base configuration utilizing a an intelligent data intensive paradigm for an appropriate scaleable information processing domain/platform.

PHASE III DUAL USE APPLICATIONS: Will test dynamic data intensive tools for dynamic (re)configurable knowledge base access and commercialize results of Phase I and II. Rapid accessibility to integrated systems and information increases choices for consumers in both civilian and defense applications. This technology could have a major impact on applications that require integrated decision making and timely and accurate information such as planning/scheduling systems, autonomous vehicles, aircraft operation, hospital life support systems, decision support systems and personal military command and control.

KEYWORDS: Software, Dynamic Data Base, Adaptive Computers, Data/Knowledge Base, Intelligent Systems, Reconfigurable Computing

AF99-123 TITLE: Flexible Information Extraction Learning Algorithm

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop and demonstrate automated statistical natural language learning algorithms that learn by example to extract multiple relationships and complex events from free text message traffic.

DESCRIPTION: Statistical learning algorithms are a new "cutting edge" approach to information extraction (IE), but to date they are only capable of shallow extraction of named entities and shallow events. This research will develop the hierarchical models and various techniques to perform "deep" levels of IE. This work includes determining when multiple relationships are expressed in a single phrase or sentence, and when the same event is described in several different places in text. Previous IE techniques have involved the use of rule-based technology, which has been ineffective at deep event-level IE.

The payoff of this research will be a substantial reduction in the time it takes an intelligence analyst to process message traffic and update his or her data bases. The result of this work will be software that can be tailored to different domains to be utilized

to perform free text extraction for the Intelligence Data Handling System (IDHS). The work also has direct applicability to the Intelligent Analyst Associate (IAA) work being performed for NAIC, the JIVA program, the National Ground Intelligence Center (NGIC) PATHFINDER program, and DARPA's TIPSTER program.

PHASE I: Develop a model of the range of possible interrelationships between named entities. The learning algorithm will be used to control the ways these different elements can be combined to produce an event. A prototype will be developed to demonstrate the feasibility of extracting multiple relationships from free text.

PHASE II:Enhance the statistical learning algorithm developed in Phase I to extract complex information extraction events of the form "Who" did "What", to "Whom", "When" and "Where" .

PHASE III DUAL USE APPLICATIONS: The results of this effort will be an enormous contribution to the IDHS and other Air Force and DoD programs that are required to manually process free-text messages. The effort also has direct commercial applicability to commercial banking, medical, and insurance establishments that are required to process textual forms.

KEYWORDS: Natural Language, Information Extraction, Statistical Learning Algorithm

AF99-124 TITLE: Improved Response to Time Critical Targets

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop technology to provide automated intelligence preparation of the Battlespace. It must allow for collaborative product analysis, exploitation, validation and dissemination. It must perform consolidation and reporting, in near real time of information from a multitude of dissimilar sensors (radar, intelligence, ESM, etc.) to provide a common tactical picture and common operational picture.

DESCRIPTION: State-of-the-art Intelligence Preparation of the Battlespace (IPB) is required to effectively prosecute time critical targets. Currently, the Air Force is developing a methodology and software tools for the development and application of computer-based IPB. However, the AF is not capable of accomplishing the required processes and products associated with IPB due to lack of primary data from the intelligence production process and from the NIMA map data production process. Both the Intelligence production process and the NIMA map data production process are highly labor-intensive which seriously limits the amount that can be produced. The data requirements for IPB require extensive current data which can not be produced by the current manual processes, which are outdated. The limited data that is produced today must still be further manually refined by the IPB analysts and operators to make it suitable for field-level use in preparation for, or execution of, a conflict.

Additionally, rapid response to time critical targets (TCTs) requires consolidation and reporting, in near real time, of information from a multitude of dissimilar sensors (radar, intelligence, ESM, etc.). Numerous agencies are independently working on some level of sensor or data fusion, but there is a gap in the USAF's capability to prosecute TCTs, e.g., theater missiles, cruise missiles, etc. The ability to sort through a complex myriad of information from multiple sources and quickly identify potential targets will allow the Air Force and other services to leap forward in the process of addressing this need.

PHASE I: Perform preliminary investigation into the technology required to provide automated Intelligence Preparation of the Battlespace (IPB). The system must produce consistent, uniform, large volume/quantity of high resolution data suitable for detailed IPB terrain analysis and must provide for dynamic IPB data base updates and dissemination. The technology investigated must perform consolidation and reporting, in near real time, of information from a multitude of dissimilar sensors (radar, intelligence, ESM, etc.), to provide a common tactical picture and common operational picture.

PHASE II:Build and demonstrate a state-of-the-art IPB system that will effectively prosecute time critical targets within the associated compressed timelines.

PHASE III DUAL USE APPLICATIONS: The capability to incorporate map and situational data without prior human review and analysis in near real time, and display a common operational picture using this data along with inputs from various types of sensors could be of value in a number of civilian government applications. It could be useful for example for traffic control, particularly in inclement weather; in congested marine areas such as harbors and heavily traveled rivers; it would have applicability in forest fire fighting; and in rescue and relief operations in widespread weather or other natural disasters. It could be used in the civilian sector to expand the capabilities and value of satellite surveillance and the accompanying results.

KEYWORDS: Data Fusion, Sensor Fusion, High Resolution Data, Common Tactical Picture, Common Operational Picture, Intelligence Production Process, Automated Intelligence Preparation

AF99-126 TITLE: Data Classification Algorithms

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop an algorithm for categorizing data points described by multiple parameter measurements.

DESCRIPTION: A data clustering system can be used for detection of anomalous or fraudulent behavior of commercial or military (both friendly and adversarial) assets. Although considerable effort has been applied to the problem of complex pattern recognition, results to date have application within narrow boundaries. The goal of this project is to develop a generic, functional method for creating groups (clusters) of similar data points where the data points are described by specifying several dozen parameter values. Each cluster should contain only those data points which are more similar to each other than to data points contained in any other cluster. A definition of "similar" needs to be developed. This definition might vary depending on the set of data points or the application which will rely upon the data clustering algorithm developed in this project.

PHASE I: Given a large (on the order of tens of thousands) set of data points, each of which has widely-varying values for several dozen parameters, determine what it means for two points to be similar enough to belong to the same classification. Potential solutions may range from simple Euclidean distance computations to neural network simulations. Ground truth classification is available for the large fraction of the data set, but a method that does not rely on development or training against a ground truth data set is highly desirable. Develop an algorithm for creating groups of similar points. Each group (or cluster) would contain a set of points that are more similar to each other than they are to points in other clusters. Furthermore, each cluster should be able to be identified or described in some manner (geometric mean, mode, centered, etc.).

PHASE II:Develop a hardware and/or software system which can create clusters as new points are introduced into the large collection of data. This system should be able to accept a new data point, quickly extract relevant parameters, decide if this new data point should be a part of an existing cluster, or if a new cluster needs to be formed. Subsequently, consider, the where the value of one or more parameters should predetermine to which cluster this new point should belong. However, if the clustering algorithm determines that this point ought to belong to a cluster other than the one predetermined by the selected parameters(s), the system ought to alert the user that there is a discrepancy. Additionally, this system should handle the case where the clustering algorithm might form several distinct clusters from one set of points with the same ground truth cluster identification, that is, a data cluster may be multi-modal.

PHASE III DUAL USE APPLICATIONS: Commercial and military communications organizations would require such a system to detect fraudulent use of their resources. The Internet, Wide Area Networks, Local Area Networks, and personal computers might require such a system to detect illegal attempts to access protected resources. Commercial and military behavior of their equipment.

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KEYWORDS: Databases, Data Reduction, Data Clustering, Fraud Detection, Anomaly Detection, Data Classification

AF99-127 TITLE: Adaptive Data Rate Control for Satellite Downlink

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop the necessary technology (Algorithms, Hardware, Software) to integrate Adaptive Data Rate Control into satellite downlink telemetry Radio Frequency Channels.

DESCRIPTION: Satellite downlink data throughput rates, which are currently too low to meet the needs of the global data user community, must be increased. The USAF is currently constrained by bandwidth, satellite transmitter power, and ground segment availability which preclude the recovery of all possible payload data. This results either in lost data or restricted payload operations. Missions using modern payloads have pushed the limits of on-orbit collection capabilities, but satellite downlinks, constrained by low power transmitters omni-directional antennas, and power/thermally constrained duty cycles are seriously deficient in throughput capability. For low earth orbiting spacecraft, the Signal to Noise Ratio (SNR) changes throughput a pass, primarily due to range, elevation and weather effects, and there are presently no good processes to optimize the data rate for these conditions. Most spacecraft radio frequency (RF) systems are designed to downlink in the worst case, ensuring reliable transmission. This fixes a low, safe data rate that will close a link in: 1) The furthest slant range (highest path loss attenuation), 2) Lowest elevations with respect to the ground station (normally 5 degrees), and 3) 95% worst day for weather (high atmospheric losses). An Adaptive Data Rate Control (ADRC) system is urgently required to provide the best possible downlink rate throughout an entire contract by monitoring SNR, Bit Error Rates (BER), and thereby optimize the downlink rate accordingly. Such systems are frequency band independent and provide the highest possible data rate. The challenges in developing such a system include the real-time evaluation of SNR and BER performance, a synchronized transition of data rate, both on the ground and on the satellite and maintaining the reliability of the data link through a data rate transition.

PHASE I: Maintain compatibility/ continuous liaison with the Center for Research Support (CERES) an Air Force satellite ground control facility; to work within the Space Ground Link Subsystem (SGLS) S-band used by Air Force operational satellites, or alternately, to develop a process designed toward a dedicated antennae a CERES operating up to K-band frequencies; to use data packet acknowledgments to ensure 100% data integrity; and have a bypass configuration to operate as a normal system. 1) Develop architecture, specifications, prototype ADRC system, 2) Develop comprehensive Phase II test plan to conduct real time demonstration with an on-orbit satellite, 3) Provide a simulated contact demonstration of prototype ADRC system.

PHASE II:1) Finalize ADRC system, 2) Provide an on-orbit proof of concept. Install ADRC system at CERES, conduct real-time contacts with an on-orbit satellite. The vehicle and Remote Ground Facility (RGF) control will be conducted remotely from CERES so that the ADRC is transparent to the Air Force Satellite Control Network (AFSCN).

PHASE III DUAL USE APPLICATIONS: The ADRC method is directly applicable to all S-band, Unified S-band, X-band, and K-band transmissions. Programs which are pressed against the upper limit of their systems can use these methods to get more throughput from their current vehicles. Customers include military and commercial satellite systems.

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KEYWORDS: RF Transmission, Data Transmission, Downlink Data Rate, Adaptive Rate Control, Satellite Communication, Space Ground Link Subsystem (SGLS)

AF99-128 TITLE: Evaluation Tool for Satellite Communication Networks Providing Guaranteed Quality of Service

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop a modeling/simulation tool for use in evaluating satellite communication networks that support virtual connections with guaranteed quality of service.

DESCRIPTION: Each virtual connection provided by a terrestrial Asynchronous Transfer Mode (ATM) network provides a guaranteed end-to-end quality of service subject to adherence by a sending user node to specified limitations on the traffic submitted to the network. In terrestrial networks, a user node often is connected to the network by a fixed link, the capacity of which may greatly exceed the cumulative demands of the virtual connections originating from the node. The node is responsible for exercising usage parameter control (UPC) to meet the specified traffic limitations. In networks that include satellite links, link capacity is an expensive resource that must be used as efficiently as possible. Consequently, the capacity from a user node may be negotiated on an as-needed basis. Tailoring the uplink capacity from a node to match the expected traffic acts as an implicit form of UPC. In a network providing virtual circuits with guaranteed quality of service, no specific resources are assigned to a connection. Therefore, the decision whether to admit a new connection is based on a statistical assessment of the consistency of the resulting cumulative traffic from both the new and the existing virtual connections and the quality of service guarantees for those connections. Current

call admission control (CAC) algorithms assume explicit UPC implemented by user nodes. The effect of UPC implicit in demand-assigned link capacity has not been addressed. A common military/commercial need exists to develop a modeling/simulation program that addresses this issue.

PHASE I: Define the architecture/specification/preliminary design of a modeling and simulation tool for evaluating CAC algorithms for satellite communication networks that support virtual connections with guaranteed quality of service and tailor uplink capacity to traffic expectations. Provide demonstrations of mutually agreed-upon key elements of this simulation tool.

PHASE II:Code, verify, and test the modeling and simulation tool (Phase I above) utilizing Air Force-supplied data.

PHASE III DUAL USE APPLICATIONS: Interest in supporting network communications over both military and commercial satellites is intense. The ability to define and evaluate CAC algorithms that take account of the special features of satellite links would be considerable interest to all areas of the satellite industry.

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1- ATM Forum Traffic Management Specification v. 4.0, April 1996, http://www.atmforum.com

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KEYWORDS: Quality of Service, Virtual Connection, Call Admission Control, Usage Parameter Control, Satellite Communications, Asynchronous Transfer Mode (ATM)

AF99-129 TITLE: Reduced-Complexity Receivers for GMSK Modulation

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop and build practical receivers for demodulating GMSK waveforms with BT products on the order of 0.1 to 0.2.

DESCRIPTION: Although the demand for military communications resources is continually on the rise, the availability of usable frequency spectrum is limited. Similarly, with the emergence of a myriad of commercial personal communications services (PCS), highly efficient utilization of available commercial frequency spectrum is paramount. In order to satisfy the growing demand on military communications capability (with a static and possibly shrinking spectral allocation) stringent requirements are placed on the signaling waveforms to be used on future satellite communications systems. Specifically, the waveforms must be bandwidth efficient, as well as power efficient, and must be robust enough to withstand jamming and other types of interference. In addition, it is highly desirable to have the modulator/demodulator as simple to implement as possible. For the commercial service providers, newly available frequency spectrum is obtained at great expense (as evidenced by the recent PCS-band auction, which totaled billions of dollars). The only way for the commercial service providers to recover such staggering initial costs and eventually become profitable is to maximize the capacity of the commercial systems. This again implies the need for bandwidth and power efficient modulation waveforms. One class of waveforms that is known to be highly spectral and power efficient is Gaussian Minimum Shift Keying (GMSK). Theoretical analyses have shown that in order to satisfy military spectral and capacity requirements the bandwidth-time (BT) product of the GMSK waveform must be sufficiently low (<0.2), and the order of the modulation must be 4 or greater. With current state of the art technology, optimum receivers for such waveforms are prohibitively complex to implement. A practical receiver design, of reduced complexity and acceptable performance, although urgently required has not been achieved.

PHASE I: Utilizing Air Force spectral/capacity requirements (above) investigate/identify/develop specific receiver design approaches for evaluation. Develop and validate computer simulation models of selected receiver designs. Based on the simulation results, and with government concurrence, select a final candidate approach and develop a preliminary specification/design. Demonstrate key elements of the selected design.

PHASE II:Finalize selected receiver design. Develop/implement a prototype of the chosen receiver design and demonstrate (mutual Government/ contractor agreed) functionality.

PHASE III DUAL USE APPLICATIONS: Although the military has high potential use for practical GMSK receivers due to stringent waveform requirements as discussed above, and since bandwidth efficiency and power efficiency are among the significant factors that determine profit margin in a commercial system, the practical GMSK receivers developed in Phase I and II will have widespread commercial interest.

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KEYWORDS: GMSK, Receiver, Waveform, Modulation, Communications, Spectral Masking, Useable Frequency Spectrum

AF99-130 TITLE: Turbo Code Decoders

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop and build space-qualified decoders for turbo codes of various rates, structures, and complexities.

DESCRIPTION: Channel coding greatly enhances error rate performance and is ubiquitous in modern communication systems. A coded channel requires much less power to achieve a given bit error rate (BER) than an uncoded channel. The cost of this ëcoding gainí is an expansion of the bandwidth required to transmit the information (i.e. the amount of bandwidth expansion, for a given bit error rate, is a function of the code rate). Over the years, many different coding schemes have been investigated by various researchers and several of these codes have become de facto 'industry standards' due to their exceptional coding gain and/or ease of implementation. Successful coding schemes include the families of convolutional codes, Reed-Solomon codes, and 'concatenate' codes consisting of constituent codes form each of the aforementioned families. In general, the concatenated codes provided the highest coding gains and were commonly used in power-limited systems with low BER requirements. In recent times, the military and the commercial sectors have both experienced the intensified utilization of multimedia services, such as electronic mail, video conferencing, and the World Wide Web. As each of these services imposes added demand on system resources, the need for coding schemes with even greater coding gains have become apparent. In recent years, a new class of powerful codes, referred to as 'turbo codes' has been invented. Based on published results, turbo codes could provide greater coding gains than any other known code. Turbo encoders are simple variations/extensions of existing codes; the decoders, however, are more complex and have not yet been successfully field tested. Space qualified turbo decoders, that meet government performance standards, are required in order to realize the gains afforded by turbo codes.

PHASE I: Based on requirements specified by the government, identify specific turbo codes of revaluation. Develop and validate simulation models of encoders and decoders for the selected codes. Develop evaluation tools, if necessary, and measure the performance of the selected codes. Based on the simulation/evaluation results, (and Government concurrence) select specific code(s) for future implementation and produce applicable prototype decoder design(s). Demonstrate key elements of the chosen decoder design(s).

PHASE II:Utilizing specifications and materials meeting government standards, finalize design/develop/build prototype(s) of decoder(s) of the selected code(s) and demonstrate Government/contractor mutually agreed-upon elements of functionality.

PHASE III DUAL USE APPLICATIONS: Turbo codes, having potentially large coding gains, will have widespread applications in any power-limited communications system, military or commercial.

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KEYWORDS: Space, Turbo Codes, Channel Coding, Simulation Models, Error Rate Performance, Turbo Encoders/Decoders

AF99-132 TITLE: High Throughput Terminal/CDMA Modem for Satellite Communications

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Apply code division multiple access (CDMA) digital technology to satellite network communications.

DESCRIPTION: Demonstrate that CDMA technology, used in the wireless communications, can be applied and result in highly cost effective satellite network communications. Theoretically, the CDMA technology used as the modem in the ground terminals, can significantly increase throughput capacity of the majority of current military and commercial satellite networking schemes.

PHASE I:1) Investigate the feasibility of applying CDMA equipment, combined with other commercial off the shelf (COTS) hardware, to satellite networking communications; 2) Simulate the improvement in networking capability; and 3) Design a prototype CDMA-based networking satellite scheme and provide a demonstration of key elements of the design.

PHASE II:1) Finalize the design of Phase I CDMA-based satellite networking scheme; 2) Procure and assemble the hardware to be used as the modem in the ground terminals plus any other required hardware/software; and 3) Demonstrate (with Air Force assistance) the advantages of CDMA-based networking satellite communications scheme.

PHASE III DUAL USE APPLICATIONS: Successful application of CDMA technology to satellite communications could significantly reduce the cost for military and commercial satellite ground terminals.

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KEYWORDS: Digital Compression, Digital Communication, Wireless Communication, Satellite Communication, Code Division Multiple Access (CMDA), Defense Satellite Communication System (DSCS))

AF99-133 TITLE: Universal Data Compression Technology

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop and demonstrate a system with the ability to compress and decompress, in real time, NTSC color video with sound by at least a factor of 1000, with good quality of reproduction.

DESCRIPTION: An important aspect of distributed Command and Control (C2) is the use of video. Video provides interpersonal communications for dispersed personnel, intelligence information from remote sensors, mission planning/execution information, and other functions. Data transfer rates of battlesite communications networks are generally far less than those required to support the transfer of time-critical data. This effort will research and develop a prototype capability which can be used on wired or wireless narrow-band communications channels. The signal processing that is responsible for the data compression/decompression shall be accomplished in real time, with a minimal processing latency. Techniques that address multiple-fidelity resolution depiction shall be addressed and employed in the demo.

PHASE I: Produce/demonstrate a conceptual design of a compression system with a compression ratio of greater than 1000:1 that operates in real time.

PHASE II:The Phase I prototype capability will be refined, extended, implemented in a hardware chip set, and demonstrated over a narrow-band channel.

PHASE III DUAL USE APPLICATIONS: Military C4I, Civilian communications networks, the Internet.

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5 - A Rational Approach to Testing MPEG-2, J. O. Noah, IEEE Spectrum May 97.

KEYWORDS: Data Compression

AF99-134 TITLE: Generic Intelligent User Interface Agent

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop a Generic Intelligent Interface Agent Architecture and Working Agent

DESCRIPTION: Computer systems are becoming increasingly complex, so complex that the average user is often overwhelmed. The recent research push for intelligent user interfaces attempts to solve the problem by providing complexity abstraction and intelligent assistance [1]. These interfaces can learn individual user preferences and tendencies to provide automated assistance, thereby acting as an "intelligent assistant" which behaves as though collaborating with the user in the work environment and can permit even an untrained user to interact effectively with a complex system [2]. This quickly emerging technology shows great promise and is a national priority.

PHASE I: Investigate the possibility of developing a generic intelligent interface agent architecture and working agent that can operate as part of the USAF Defense Information Architecture (DII) Common Operating Environment (COE). This architecture must be compliant with DII COE requirements and perform complexity abstraction and intelligent assistance for applications residing in the COE.

PHASE II:Develop the architecture and implement a DII COE compliant generic intelligent interface agent that provides complexity abstraction and intelligent assistance to COE applications. The agent must demonstrate clear advantage in user workload reduction and ease of use within an existing COE application when compared to the original application.

PHASE III DUAL USE APPLICATIONS: Intelligent interface capabilities can be used in a wide range of military systems, from agents managing electronic mail arriving at a desktop computer [2] to agents autonomously presenting a fighter pilot with time-critical engagement information in the cockpit [5]. These capabilities can also be used in numerous commercial applications; for example, prioritizing executive corporate correspondence, or workload reduction in the cockpit of a modern commercial airliner.

KEYWORDS: Intellligent Assistant, Complexity Abstraction, Intelligent User Interfaces

AF99-136 TITLE: Intelligent Web Assistant

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop Dynamic and Adaptive Data Mining Techniques for Designing, Developing, and Accessing Large-Scale Data/Knowledge Bases for Intelligent Information Systems

DESCRIPTION: In order for the USAF to fully exploit the Internet and achieve information superiority, it must have web search agents that intelligently mine information from the vast amounts of on-line data. These agents can utilize current natural language capabilities to provide an "Intelligent Web Assistant" that doesn't merely search for keywords, but in fact retrieves and reports information.

PHASE I: Perform preliminary investigation into the incorporation of natural language understanding into a Web search agent that mines and reports information rather than keywords. Investigate the feasibility of integrating multimodal human-computer interaction to include natural language, graphical presentation, and voice recognition. Finally, investigate feasibility of "fire and forget" paradigm of intelligent Web mining to minimize the need for human interaction.

PHASE II:Build an intelligent Web agent that will mine Internet resource and report information, not just keywords, through a multimodal human-computer interface. This search agent will provide multimodal human-computer interaction to include natural language, graphical presentation, and voice recognition. The agent will also be "fire and forget", able to search and compile results with minimal human interaction.

PHASE III DUAL USE APPLICATIONS: An intelligent Web assistant will allow the military to fully exploit Internet resources to achieve information superiority over the Internet's vast resources. Such an agent will be invaluable to users throughout industry and academia.

KEYWORDS: Data Mining, Intelligent Web Assistant, Intelligent Information System, Multimodal Human-Computer Interaction

AF99-137 TITLE: Complex Modeling of Software Components

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Investigate the Ability to Model Complex Software Architectures as a Collection of Components.

DESCRIPTION: Recent improvements in software development techniques have led to the creation of very large scale architectures as a collection of software components. The current constructive simulation community creates unique simulation exercises using a collection of simulations and simulators that interface in a varying number of ways. Many of the components represented in the simulation are funded and developed by different organizations. This has led to a large scale configuration problem that requires

costly testing and integration efforts, as well as costly deployments and use. In recent years, modeling techniques have matured enough to be able to represent the specification of software architectures and capture of its collateral information. Applications using these models can support an architecture's testing, integration, deployment, and use. These applications have the potential to greatly reduce the costs involved in these activities, while increasing the overall quality of the architecture's use. PHASE I: Demonstrate the feasibility of using modeling techniques to represent the complex configurations of the constructive simulation community. Specifically, the modeling techniques and technology investigated should be able to represent semantically rich information about software architectures and their interfaces. The representation should support the composition of applications from the software architectures. In addition, collateral information on the deployment and use of an architecture should be able to be associated with the components represented. The approach investigated should be able to be embedded in applications that end-users in the constructive simulation community can use to support simulations. PHASE I will document an approach for modeling this information and a plan for producing supporting technology.

PHASE II: Implement a tool or technique that can represent the arbitrarily complex configurations of software architectures. While the tool or technique should be general enough to apply to any software architecture, the particular area of interest is the constructive simulations community. PHASE 11 should demonstrate the technology by building a model ofthe software used during constructive simulations, and several applications that use the model to support constructive simulations exercises.

PHASE III DUAL USE APPLICATIONS: This approach and possible application have applicability to both the government and commercial marketplace. Large-scale architectures are being constructed in industry, particularly in the financial and telecommunications market, that are requiring greater need for automated configuration support. In addition, government procurements for large-scale object-oriented systems will produce architectures premised on composable components to create unique applications. These applications require sophisticated composition techniques and technology similar to results expected in PHASE II.

KEYWORDS: Modeling, Simulation, Automated Synthesis, Model Based Synthesis, Software Architecture, Inter-Linked Knowledge, Constructive Simulation, Knowledge Based Software

AF99-138 TITLE: VHDL Based ULSI to VLSI Design Partitioning Tool

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Enable the implementation of ULSI ASIC system functionality through innovative design partitioning technology at the VHDL level.

DESCRIPTION: Present synthesis tools are oriented to single die implementations. For many reasons, the designer needs the capability to automatically partition the design at arbitrary levels of abstraction (behavioral, presynthesis RTL, and post Synthesis RTL), and across multiple devices based on user specified constraints. Gate densities for future DoD system ASICs (Application Specific Integrated Circuits) will be greater than one million gates. Scaleable, automated, and interactive design synthesis and partitioning tools are desired that would allow the optimized generation of ULSI (Ultra Large Scale Integration) VHDL (IEEE 1076) (Very High Speed Integrated Circuit Hardware Description Language) designs into several smaller VLSI gate designs integrated onto a common Multi-Chip Module (MCM). These tools must be designed to: 1) facilitate the optimized design partitioning process, 2) aid in chip level I/O placement and drive selection, 3) allow for the modeling and back annotation of MCM interconnect delays and load for timing simulation into the VHDL models, 4) maintain desired performance, 5) automatically insert the appropriate IEEE 1149.x test structures for each component and MCM, 6) automatic generation of VHDL test benches and WAVES (IEEE 1029.1) test vectors for each component, and MCM, and 7) easy targeting to arbitrary cell libraries and semiconductor processes, including Radiation Hardened processes. The result of this effort will be a general software tool capable synthesizing > 1M gate VHDL designs and partitioning the design into an arbitrary number of die based on user specified constraints.

PHASE I: Activity shall include (but not be limited to): 1) a specific functional definition of the ULSI to VLSI synthesis and partitioning tool, 2) identification of appropriate user interfaces and symbolic representations, 3) a comprehensive overall preliminary system design, 4) demonstration of ULSI to VLSI synthesis/partitioning tool integration with existing Electronic Design Automation (EDA) ASIC design flow, and 5) an Air Force/contractor agreed upon preliminary demonstration of system building blocks.

PHASE II:Activity shall include (but not be limited to): 1) Completion of the ULSI to VLSI synthesis/partitioning tool software system, 2) full scale demonstration of the system on a 1M+ gate design (design provided by Air Force), 3) targeting to an Air Force Specified MCM process and using at least one radiation hardened parts suppliers' ASIC library, and 4) a simulated comparative performance analysis of the unpartitioned design to the multi-component partitioned design in accordance with the above (Description Section) requirements.

PHASE III DUAL USE APPLICATIONS: Successful development of a scaleable, automated, interactive design synthesis/partitioning tool will be in demand by both commercial and DoD microelectronics communities. A number of DoD uses will come from space system developers because radiation-hard processes are typically lower density than standard processes. A significant commercial use of this technology is expected to be in the commercial space telephony, communications, and resource imaging sectors. Additionally, it is applicable to both military and commercial products where high performance, tightly coupled ASICs on common MCM substrates are utilized because their circuitry is too large to fit onto a single silicon die; such as many digital signal processing applications, real time medical imaging, logic emulation, high speed computing, dedicated parallel processors, and resource constrained devices such as Gate Arrays, FPGA's, PLD's etc.

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3. M. Shih, E.S. Kuh, R.S. Tsay, Performance Driven System Partitioning on Multi-Chip Modules, Proceedings of the 29th ACM/IEEE Design Automation Conference, pp. 53-55, 1992.
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KEYWORDS: VLSI, VHDL, IC Layout, Microelectronics, Multi-Chip Modules, Design Partitioning

AF99-139 TITLE: VHDL Text-to-Graphics Translation and Text/Graphics Co-Simulation

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop products to support the design, modeling, and simulation of complex digital microelectronic systems and to enable re-use of existing models.

DESCRIPTION: Very High Speed Integrated Circuits (VHSIC) Hardware Description Language (VHDL) is an IEEE standard language for definition, simulation, and synthesis of digital systems. Several graphical and symbolic tools are available for capturing VHDL textual descriptions, but there is not a complete set of VHDL text-to-graphics and graphics-to-text tools. Schematics, block diagrams, data-flow graphs, state diagrams, structural hierarchy maps, flow charts, data dependency graphs, etc. can be extremely valuable in understanding models and finding problems in models. Such capability would lower the cost of creating new models and support reuse of existing models. Designs captured graphically should be intermingled with text generated designs. This is because a given design or portion of a design will lend itself more to one modeling technique or representation than to another depending upon the nature of its functionality. The designer should be given the freedom to choose and efficiently utilize the representation most natural to the problem. VHDL source should automatically be generated from the graphical representations and graphical representations generated from text. They may be freely interspersed in any order. Simulation should be automatic from any representation or mix. Test benches should be automatically generated for graphical representations. Captured test vectors should be converted from graphics-to-text. The test vector text format should be the Waveform and Vector Exchange Standard (WAVES - IEEE 1029.1). This topic solicits research and development in VHDL text-to-graphics and graphics-to-text tools. Additionally or alternatively this topic solicits research and development in co-simulation of multiple logic modeling representations.

PHASE I:The preliminary design of the tool will be performed. The functionality, user interface, and design environment interface will be completely specified.

PHASE II:The tool will be constructed, evaluated, and demonstrated. Reference manuals and user guides will be developed.

PHASE III DUAL USE APPLICATIONS: The design automation tool will be readied for market and tested by potential electronic design customers in the military and commercial design communities. Production, marketing, and support plans will be developed. All tools developed under this topic will be inherently dual-use. This is because the same methods used to design electronics for military systems are applicable to commercial systems.

KEYWORDS: Graphical Design, Microelectronics, Software Computing, Modeling and Simulation, Integrated Circuit Design, VHSIC Hardware Description Language (VHDL), Application Specific Integrated Circuit (ASIC)

AF99-140 TITLE: Immersive Wargaming

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop an immersive wargaming environment in which users could "experience" past or present military conflicts.

DESCRIPTION: This effort involves a marriage of the enabling technologies of virtual reality, modeling and simulation, game theory, human-computer interfaces and distance learning. In an immersive wargame, a (virtual) battlefield commander would be capable of viewing all aspects of an on-going conflict within a realistic synthetic environment, using a multi-sensory interface system. This effort would result in a hybrid software/hardware synthetic environment in which a user (player) could be fully 'immersed' into a synthetic (initially, modern battlefield) environment. Central to this development is the extensive leveraging of practices and tools arising from recent advances in Distributed Interactive Simulation (DIS) and the emerging High Level Architecture (HLA) protocol. Ultimately, this activity would culminate in a valuable 'edutainment' tool, whereby would-be decision-makers could play armchair general within any of a library of historical conflicts which would be played out (simulated) against other live players, or a doctrinal rule set. Technology can also be used for small unit tactics practice/team play for soldiers/pilots through company/squadron commanders and higher level command functions. This would also allow units to practice in territory that does not provide the "known solutions" of current unit practice areas (e.g., Fort Irwin, Red Flag, etc.). It promotes team-building and unit cohesion, promotes research into the concept of "dynamic campaign assessment" and otherwise allows for realistic simulation of the "fog of war." This effort would be structured into three logical phases, as follows:

PHASE I: Develop an advanced DIS/HLA tool and protocol, along with virtual reality concept and equipment, to effect a maintainable, repeatable present-day military conflict, such that it could be used to immersively train potential decision-makers. Current COTS software (Marathon, DamageInc., etc.) might be used as a starting point for user interface software.

PHASE II: Extend the conflict domain to include past conflicts (e.g. Grenada, Falkland Islands, Desert Storm, Battle of Oriskany, Battle of Shiloh Church, etc.) in a plug-compatible conflict/scenario library.

PHASE III DUAL USE APPLICATIONS: The ultimate market is the burgeoning edutainment market; from teens interested in testing their mettle against the Pattons or Grants of the past to philosophical historians (e.g., what would have happened if Eugene McCarthy had won the presidential election?).

KEYWORDS: Wargaming, Simulation, Synthetic Environments, Modeling and Simulation, High Level Architecture

AF99-141 TITLE: Defensive Information Operations Planning Tool

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop an knowledge-based tool to predict information system vulnerabilities, identify threats, and model/simulate attack results on these systems.

DESCRIPTION: Current Vulnerability Assessment and Risk Management methodologies are static and do not operate in real-time on dynamically changing information systems architectures. The vulnerability assessment is performed, the vulnerabilities are identified and recommended countermeasures are provided. From here it is up to the operator to install the countermeasures based on some cost benefit analysis or assume the risk. These assessments are performed on a periodic basis and do not account for the dynamic Information System changes that occur daily or in a mobile warfare scenario. Additionally, these assessments are performed after the information system is deployed; in many cases this is too late and vulnerabilities are already being exploited before the assessment has been performed, leaving the enemy holes to install future attack backdoors into the Information system. A planning tool is required that allows for the modeling of the planned deployed Information system architecture. From this model, blue force information system vulnerabilities can be explained relative to their significance to performing mission critical tasks, countermeasures can be applied and their success tested by simulating Information attacks. This model can then be used for the deployed Information system architecture and once deployed, dynamic changes in the architecture can be detected by continuous monitoring. These changes will trigger the planning tool to effect a change in the model and the reassessment and generation of new Course of Action (COA) options for the deployed architecture.

PHASE I: Develop a plan for creating automated/semi-automated knowledge-based tools capable of assessing information system vulnerabilities, identifying threats, and performing modeling/simulations of attack results on these information systems.

PHASE II:Create automated tools which will afford an operator the opportunity to assess vulnerabilities and risks, investigate a number of countermeasures to notional attacks for defense optimization, and provide Course of Action (COA) options for real-time reaction in a dynamically changing warfare scenario. Demonstrate a prototype knowledge-based defensive information planning tool on an Air Force scenario.

PHASE III DUAL USE APPLICATIONS: Security of information is extremely important to corporations, banking, and financial institutions, the automated tools developed under this effort can be applied to assist them in assessing their information vulnerabilities and developing courses of action to minimize the threats they face.

KEYWORDS: Risk Assessment, Modeling and Simulation, Knowledge Based Planning, Information Vulnerabilities, Defensive Information Operation, Automated Course of Action (COA)

AF99-142 TITLE: Media and Medium Control for Optimized Internetworking

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop system for intelligent optimization and internetworking for software radio pre-planned product improvement (P3I)

DESCRIPTION: Considering the soon-to-be-developed Software Defined, Digital, Reprogrammable Radio for the services (Joint Tactical Radio System, or JTRS), we need to be planning for the next generation of improvements to a JTRS, given the starting point of a fully (RF through I/O) modular, open, scalable and re-programmable system [with spare processing and memory (storage) capacities]. With a software radio which can be controlled and optimized with resident system software, what adaptive and intelligent control can be developed to enhance networking and quality/speed of service? Intelligent manipulation or adaptation of at least five functions can enhance the military radios of the future, and improve the digitized battlefield information flow.

PHASE I: Routing and switching, multiplexing and de-multiplexing, dynamic packet-control (size, structure, etc.), prioritization and preemption of service, adaptive control of media and/or channel-selection all need to be investigated as a system for intelligent optimization and internetworking. Intelligent optimization also includes: metric gathering, analysis, assignment and apportionment, monitoring and tracking of system resources. Study and analyze what software radios will need (resources, information, algorithms, etc.) to employ these control features. Develop model to determine which will provide the best pay-back in cost-effectiveness, and capability. Initial focus should be on network implications of such optimization.

PHASE II:Design, develop, and demonstrate in a laboratory environment the capabilities identified as most promising in Phase I.

PHASE III DUAL USE APPLICATIONS: Intelligent optimization of resources is useful for commercial as well as military applications. Any user (Civil, Military, or Commercial) who requires optimization for quality or speed of service will need such technology.

REFERENCES: Operational Requirements Document (ORD) for Joint Tactical Radio (JTRS), 11/14/97

KEYWORDS: Digitized Battlefield, Routing and Switching, Dynamic Packet Control, Quality and Speed of Service, Multiplexing and De-Multiplexing, Prioritization and Preemption of Service, Modular/Open/Scalable/Reprogrammable Systems, Software Defined Digital Reprogrammable Radio

AF99-143 TITLE: DII COE Component Framework

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Rapid application development/deployment within DII COE using component-based technologies.

DESCRIPTION: Distributed component applications are the next revolution in software development. A growing number of DOD and industry efforts are beginning to prove this technologyís promise of widespread software reuse, low-cost platform requirements, and rapid design-to-field cycle time. The reusable nature of components is the backbone behind their innovation. The commitment of companies such as Microsoft, Sun Microsystems, and IBM, to deliver end-to-end solutions for building and operating distributed component applications is enormous. If each solution were based on a single component standard, the specification for implementing and invoking a componentís functions, a component developer could use a mixture of cross-vendor products to build and execute the application. However, because the stakes are so high in becoming the defacto standard, the market has divided into three competing technologies for distributed component applications ñ Distributed Component Object Model (DCOM), Common Object Request Broker Architecture (CORBA), and Java. While each group is rapidly advancing their component-based product line, application developers are left with the decision of which technology to embrace. The creation of a component framework, which transcends the competing component standards, will enable application developers to assemble applications from components written

by any vendor, in any language, using any interface standard, for their particular infrastructure. This would maximize the chief contribution of component-based development ñ leveraging other developerís efforts to construct powerful, inexpensive, and robust applications in record time frames. A developer focused on a Windows NT environment, geared to support DCOM, could still use components created by another developer who focused on a Unix environment supporting CORBA. The commitment of the Defense Information Infrastructure (DII) Common Operating Environment (COE) community to Windows NT and Unix platforms makes DII COE an obvious target for a component framework specification. This effort will prototype and evolve a component framework for DII COE application developers as it builds a DII COE-compliant distributed component application using both DCOM and CORBA based components and demonstrates its operation on a DCOM, CORBA, and Java distributed component platform (DCP).

PHASE I:Develop and demonstrate a DII COE-compliant distributed component application, using DCOM, CORBA, and Java based components. Propose a prototype component framework which aides in the construction of this application for each DCP.

PHASE II:Develop and demonstrate distributed component applications for the DCOM, CORBA, and Java DCPs using the prototype component framework. Identify proposed framework improvements for DII COE application developers.

PHASE III DUAL USE APPLICATIONS: Develop and implement a business plan for marketing the component framework to DII COE application developers and upgrading the framework to support developers for other infrastructure environments. Component frameworks are widely regarded as the missing link in realizing the tremendous potential of distributed component applications. A framework developed for the DII COE community will be extensible to the entire software engineering community at large.

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KEYWORDS: Java Components, Hardware Clustering, Component Frameworks, Multi-Tiered Architectures, Distributed Component Applications, Distributed Component Object Model (DCOM), Common Object Request Broker Architeecture (CORBA), Defense Information Infrastructure Common Operating Environment

AF99-144 TITLE: Rapid Prototyping Environment for Information System Design and Acquisition

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Build a distributed simulation environment to assure mission-specific system performance and develop system-level databases

DESCRIPTION: This program will build, document, and validate a generic distributed modeling and simulation environment which can be used by product development teams to rapidly quantify the performance of a proposed design against a documented set of operational requirements in a specified scenario. This environment will make maximum use of the results of the DARPA-sponsored Simulation Based Acquisition program and use the AFRL Collaborative Engineering Environment as its backbone. The environment will accommodate multiple engineering disciplines (e.g., mechanical, electromagnetic, thermal) and takes into account the mutual effects of the physics associated with the respective engineering disciplines. The environment will provide for the collection, storage, distribution, and configuration control of all data associated with a system and its various subsystems, equipment's, and components. This system-level database will be available for future enhancements, upgrades, and replacements of any unit within the system.

PHASE I:The initial environment will contain a suite of electromagnetics, mechanical, and thermal simulation programs suitable for use in antenna design, assessing its performance in the presence of the surrounding structure. Collaboration and distributive processing via the Collaborative Engineering Environment and using the tools and processes developed under the Simulation Based Acquisition project will be demonstrated. An initial schema for the product model at the engineering level will be developed and demonstrated.

PHASE II:Extend the original engineering set to include other disciplines (e.g., flight dynamics), and develop suites of tools for other products or applications (e.g., education, MEMS), developing and extending product models as necessary. Develop software utilities to assist in the interface/insertion and maintenance of analysis tools within the environment, and tools for the development and use of the schema for the product model.

PHASE III DUAL USE APPLICATIONS: Military applications include command and control, communications, intelligence, surveillance, and reconnaissance. Civilian applications include commercial transportation, public safety, and wireless communications. The framework and optional suites of tools would reduce the cost and increase the effectiveness of engineering education. Rapid prototyping would enable a quicker transition from basic research to products which increase the quality of life, minimize the risk of mass marketing a defective product, and reduce the cost to market while increasing the quality of the product.

KEYWORDS: Aircraft Modeling, Virtual Prototyping, Digital System Models, Concurrent Engineering, Modeling and Simulation, Collaborative Engineering, Distributed Interactive Simulation

AF99-145 TITLE: Low Temperature Compression Set Resistant O-ring Material

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop low temperature and compression set resistant elastomeric materials for use in constructing aircraft fuel and hydraulic seals.

DESCRIPTION: Current materials used to construct aircraft hydraulic and fuel seals are required to seal at -650F or -400F depending on the aircraft system. Current materials, such as nitrile and fluorosilicone, that can seal at such temperatures are very prone to compression set. In a relatively short period of time the seals lose their elasticity and, consequently, their ability to seal.

The current fuel system seals are required to be resistant to all types of aircraft jet fuels, including JP-4, JP-5, JP-8 and Jet A. They are required to operate at temperatures between -650F and 1600F at low pressures. Recent advances in aircraft thermal management have increased the return temperatures of the fuel to 2250F. Therefore, new materials should be capable of sealing from -650F to 2500F. Since the Air Force converted to JP-8 fuel, there has been a debate to raise the low temperature to -400F. This is because JP-8 has a slush temperature of about -500F. Proposals for a good compression set resistant material that has a -400F to 2500F operating range will be considered.

Current aircraft hydraulic systems normally operate in the -650F to 2750F temperature range at pressures of 3000 to 4000 psi. The weakness of the elastomeric materials requires the use of plastic back-up rings to prevent extrusion of the seals at high pressures. The low temperature requirement in some systems is -400F and other current systems that require -650F may relax the temperature requirement to
-400F. Therefore, proposals for compression set resistant materials that can achieve a -400F to 2750F will be considered.

Nitrile seals are heavily plasticized in order to obtain the low temperature capability; however, this also makes the material very weak especially in the area of compression set. Both hydraulic seal and fuel seal formulations are effected by this. However, there are some recent developments with hydrogenated nitrile materials that may make it possible to develop a low temperature compression set resistant material. Fluorosilicone seals that are used in fuel systems are also very compression set prone due to the inherent weakness of the material backbone. Fluorocarbon materials have not been able to achieve the low temperature requirements. Even the low temperature formulations do not obtain a -400F sealability. This material is very good in every other way and would be the material of choice if the low temperature requirements could be met without giving up on any of the other properties.

PHASE I: Define, determine feasibility, and show proof of concept for preliminary low temperature and compression set resistant hydraulic and fuel seal materials. Select and evaluate promising formulations of candidate materials. These materials shall be applicable for substitutes for MIL-P-5315, MIL-R-25988, and MIL-P-83461 seal materials.

PHASE II:Further develop, optimize, and scale up candidate material(s) from bench scale to arger quantities for extensive physical properties testing. Test materials in static and dynamic seals test fixtures. Develop and execute a technology transition plan for the best materials to commercial application.

PHASE III DUAL USE APPLICATIONS: The materials and technology developed under this program would have numerous dual use applications. The most obvious is for commercial fuel seals. Technology may also be applicable off-road vehicle seals.

KEYWORDS: Low temperature, Aircraft fuel seals, Aircraft hydraulic seals

AF99-146 TITLE: Development of Static Dissipative Hard Laminate Surfaces

TECHNOLOGY AREA: Materials, Processes and Structures

OBJECTIVE: Develop a cost effective product that will pass MIL-PRF-87893B performance specifications for a Type I Rigid Worksurface.

DESCRIPTION: Electrostatic charge dissipation on worksurfaces has been well documented to prevent considerable damage to electronic components during their handling. Charge dissipation has been successfully implemented in the softer, more pliable worksurfaces (Type II and Type III of MIL-PRF-87893B). These materials are made from polyvinyl and rubber doped with conductive ingredients. Although the current hard laminates (Type I) possess acceptable resistance values in the range of 1 x 106 to 1 x 109 ohms, they do not dissipate charge from items placed upon them. This is most likely due to high contact resistance between the aluminum disk and the worksurface. The complete test methods for evaluating charge dissipation and other electrical properties of all three types of worksurfaces are described in MIL-PRF-87893B. Most of the current hard laminates for counter tops

are made from thermoses melamine resin impregnated into paper products and formed under high pressure and heat. A variety of electrically conductive components (fibers, ions, salts, etc.) have been added into a subsurface portion of the laminate to promote charge dissipation. The surface resistance of the very topmost layer may be a key to passing the Charge Dissipation Test. Conductive organic polymers which are compatible with melamine resin may reduce the surface resistance. Hard laminate surfaces are preferred over softer surfaces for their durability (i.e., cut, puncture, and abrasion resistance) cleanability and writing surface. Humidity is known to affect the ability of a surface to dissipate electric charge. A surface is more likely to fail to dissipate a charge at 10% rather than 50% relative humidity. Air Force electronics are particularly vulnerable to electrostatic discharge (ESD) because they are often exposed to very dry or very cold conditions that promote static discharge.

PHASE I: Identify materials that effectively overcome the surface phenomena mentioned above and additionally meet all performance requirements of MIL-PRF-87893B in a cost effective manner. This means that the present industrial process should be changed as little as possible to implement the solution. Evaluate the compatibility of these materials with melamine thermosetting resins and the process commonly practiced in hard laminate production. Perform preliminary testing of the materials in accordance with MIL-PRF-87893B.

PHASE II: Thermoanalytical, thermomechanical and theological characterization shall also be generated on the candidates which look most promising and compared to materials currently used. Prepare small-scale laminates (23 x 23 inches) using technology developed in Phase I and having the thickness specified for Type I materials in MIL-PRF-87893B. These will be tested according to MIL-PRF-87893B. The Air Force will participate in the testing effort.

PHASE III DUAL USE APPLICATIONS: Several large companies in the business of producing counter tops could benefit from new technology derived from this effort. The Air Force in particular and the electronics industry as a whole would benefit from hard laminate worksurfaces that truly remove the charge on items placed upon them.

REFERENCES: MIL-PRF-87893B. US Patents: 4784908, 5244721, 5275876 (Nevamar); 4540624 (Westinghouse); 4454199, 4455350, 45899S4, 4645717, (Charleswater); 4891264 (Chisso); 4472474 (Formica).

KEYWORDS: Static dissipative worksurface, Static dissipative laminate, Melamine hard laminate, Conductive polymer & melamine.

AF99-147 TITLE: Removal of Oxide Films from Nickel Based Superalloy Fracture Surfaces

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Develop an inhibited chemical etchant to remove oxide films from nickel based superalloy fracture surfaces.

DESCRIPTION: Failure of nickel superalloy gas turbine engine components during operation leads to the formation of oxide films on the unprotected fracture surfaces. Failure analysis of these components is made difficult, if not impossible, in many cases by the masking nature of these layers. Current fracture surface cleaning techniques (acetate film replication and plasma etching) prove themselves inadequate at removal of the oxide films and preservation of the fracture surface, respectively. Inhibited chemical etchants to remove oxide films from steels have been developed to preserve the base metal during pickling in the manufacturing processes. No similar process is required during nickel superalloy production and, therefore, no such inhibitor has been developed.

PHASE I:Advance research into the development of an inhibited chemical etchant for the IN-100 nickel superalloy system. Perform an analysis of the chemical reactions required to remove the oxide films that form when exposed to high temperature combustion gases while being inhibited from attacking the IN-100 basic composition. Develop inhibited etchant(s) that may reproduce these reactions. Develop a test methodology and matrix for the testing of the developed etchant on IN-100 as well as other selected nickel based superalloys. Document all work in a report format.

PHASE II:Produce and document fracture surfaces (tensile, fatigue and stress rupture) per the Phase I test matrix. Expose fractures to a gas turbine type environment to produce oxide films of varying degrees. Attempt to remove films by acetate film replication. Document results. Remove oxide films using developed etchant(s) per matrixed test procedures. Document results and compare to clean fracture.

PHASE III DUAL USE APPLICATIONS: A successful inhibited chemical etchant would benefit the entire aerospace engine industry by allowing improved failure analysis of governmental and commercial gas turbine and rocket components. Such an inhibited etchant may also find application as a nondestructive cleaning agent.

KEYWORDS: Nickel, Fracture Cleaning

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AF99-148 TITLE: High Temperature Structural Materials for Advanced Space, Missile, and Aircraft Systems

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Develop and characterize advanced high temperature structural materials.

DESCRIPTION: Advanced high temperature structural materials are required to meet the performance objectives of future Air Force space, missile, and aircraft systems. For example, these materials are critical to doubling the propulsion capability of rocket engines and gas turbine engines, and for extending the range of uninhabited air vehicles. Their application will enable the attainment of Air Force goals for global reach and global power. New approaches are requested to develop and characterize (a) advanced high temperature structural ceramic composites (1800|F to 3500|F, excluding carbon-carbon composites), (b) intermetallic materials and composites (1800|F to 3000|F, excluding nickel aluminides) and (c) model forming processes for advanced structural materials. For ceramic composites, research is focused largely on continuous fiber reinforced ceramic matrix systems and may include the following: (a) new, unique ceramic composite development; (b) novel matrices suitable for continuous fiber reinforcement (applicability to composites must be demonstrated), (c) fiber/matrix interface treatments engineered for toughened behavior and stability; (d) continuous ceramic fiber development; (e) interpenetrating multiphase oxide structures where the mechanical properties are limited by the interphase spacing, not the grain boundaries (f) test techniques to determine mechanical and physical behavior (such as failure modes, crack and void growth, oxidation, stress-strain, cyclic stress-strain, etc.) as a function of temperature and loading history; and (g) analytical modeling of composite behavior. For intermetallic materials, research is limited to: (a) methods for modeling intermetallics which lend insight into chemistry selection and control, as well as microstructural selection and control; and (b) methods of synthesizing bulk quantities of intermetallics to provide chemistry and microstructural control on a submicron scale while maintaining the ability to vary and control the final microstructural scale. For modeling of forming processes, research may include modeling of (a) the unit forming process; (b) the material behavior in response to the demands of the unit process; (c) the interface between the work piece and the die or mold; and (d) novel methods for obtaining physical property data and constitutive equations for insertion in models. Modeling effort may be directed at rapid prototyping and/or solid freeform fabrication for the above materials.

PHASE I: This program will focus on the critical issues which when successfully addressed, will provide proof of concept. Proposal should demonstrate reasonable expectation that proof of principle can be attained within Phase I.

PHASE II:This program will be structured to develop and refine those feasible concepts to the point where performance is demonstrated on a scale sufficient to permit an assessment of the ultimate application potential to help meet Air Force advanced materials needs.

PHASE III DUAL USE APPLICATIONS: The developed approaches would have broad commercial applicability due to the large number of commercial air, space, and engine systems that have materials requirements of a very similar nature to those faced by the DoD. These materials are critical to affordable access to space for both the military and commercial sectors, where their use in light weight, high temperature, durable propulsion and thermal protection systems is critical. Various energy conservation applications, e.g., radiant burners, heat exchangers, power turbines, and hot gas filters are also pertinent. For the turbine applications in particular, these materials permit more efficient and clean operation, saving precious natural resources while limiting pollutant emissions.

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1. "Ceramic Engineering & Science Proceedings: 21st Annual Conference on Composites, Advanced Ceramics, Materials, and Structure," 18[3-4], The American Ceramic Society (1997).
2. R. J. Kerans and T.A. Parthasarathy, "Theoretical Analysis of the Fiber Pullout and Pushout Test," J. Am. Ceram. Soc., 74 [7] 1585-96 (1991).
3. A.G. Evans and D.B. Marshall, "The Mechanical Behavior of Ceramic Matrix Composites," Acta Metall., 37 [10] 2567-83 (1989).
4. D.M. Dimiduk, M.G. Mendiratta, and P.R. Subramanian; "Development Approaches for Advanced Intermetallics Materials - Historical Perspective and Selected Successes," in Structural Intermetallics, R. Darolia, J.J. Lewandonski, C.T. Liu, P.L. Martin, D.B. Miracle, M.V. Nathol eds., The Minerals, Metals, and Materials Society (TMS), Warrendale, PA (1993) p. 619-630.

KEYWORDS: Fibers, Ceramics, Interfaces, Composites, Intermetallics, Process Modeling, Characterization, Environmental Protection

AF99-150 TITLE: Lightweight Metallic and Metallic Composite Materials for Aircraft and Space

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Develop innovative approaches for improving the performance, durability, and cost-effectiveness of lightweight metallic and metallic composite materials.

DESCRIPTION: Metals based on aluminum, titanium, and their alloys and composites are key structural materials used in the construction of current vehicles and propulsion systems for air and space. The selection of which particular material to use for any given component involves a consideration of (1) that material's expected mechanical and environmental performance under the specific conditions involved and its resultant durability, (2) any effects of that material choice on system weight and center of gravity, and (3) the cost of producing the material, manufacturing the component, and the costs to maintain, repair and replace the component. While the specific levels of these requirements and the optimum balance between them varies between specific applications, the requirement to do more and cost less with structural materials is pervasive. This translates to a continuous need to improve the fundamental understanding of these materials, a continuous innovation in the microstructural approaches used for their development, and continuous creativity in the processing used to manufacture raw materials, as well as components. For lightweight metals, novel approaches for alloy development, heat treatment, processing, and characterization of conventional and advanced structural metals/MMCs are sought which might result in improved material performance and durability, reduced weight, and/or reduced cost for specific vehicle structure or engine applications. For example, in the area of discontinuously reinforced metals, new approaches might be proposed to develop improved materials, production methods, prediction tools, and fabrication schemes for aerospace structural and electronic packaging applications which: a) significantly reduce the cost of producing/maintaining a flight-worthy finished component; b) increase key materials properties such as fracture toughness, strength, stiffness, fatigue life, creep, and high temperature stability; or c) enhance predictive capabilities for composite materials properties and processing in ways which widen the scope of their application.

PHASE I: The end product of a Phase I program would be the establishment of the technical feasibility for the proposed approach. Initial economic feasibility would also be required, if applicable. All of the critical material issues involved with the selected approach will have been addressed.

PHASE II:The technology developed in Phase I would be refined, matured, and possibly scaled up, in Phase II. The ability of the technology to meet Air Force needs would be demonstrated.

PHASE III DUAL USE APPLICATIONS: As the structural metals and metallic composites used in both military and commercial aircraft/spacecraft are similar, it is anticipated that there would be broad applicability for the technology developed here.

REFERENCES:
1. "Titanium Castings: From Turbine Engine to Airframe," Modern Metals, vol. 51, n. 4, 1 May 95, p. 58R.
2. E. A. Starke, Jr. and J. T. Staley. "Application of Modern Aluminum Alloys to Aircraft," Progress in Aerospace Sciences, vol. 32, n. 2/3, 1996 p. 131.
3. "Spray Forming Could Cut Component Cost," Aviation Week and Space Technology, vol. 146, n. 11, 17 Mar 1997, p. 102.
4. "Aluminum Composite Doubles Lifetime of F-16 Ventral Fin" Advanced Materials & Processes, ASM International, Oct. 96 p.7.
5. "Wright Laboratory Success Stories, A Review of 1996," Wright Laboratory, WPAFB, OH 1997, pp. 56, 151. WL-TR-97-6002, ADA 323 748.

KEYWORDS: Cost, Titanium, Aircraft, Aluminum, Magnesium, Durability, Processing, Composites, Performance, Sustainment, Space vehicles, Heat Treatment, Turbine engines, Process Modeling, Characterization, Alloy Development, Structural Metals, Metal Matrix Composites, Discontinuously Reinforced Metals

AF99-152 TITLE: Laser Radar Techniques for Multi-Station Vibration Monitoring

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Investigate the use of laser radar techniques and fiber optics for monitoring machine tool vibrations at multiple locations.

DESCRIPTION: Machine tool vibration related problems encompass poor surface finish, reduced dimensional accuracy, increased cutting tool wear and fracture, and even damage to the machine tool itself. Chatter, the most limiting form of vibration, also causes noise levels that exceed acceptable limits. There is the potential to encounter chatter in any machining operation. Present day production machine tools are designed to control vibrations by optimizing the mass and stiffness characteristics of the structure,

and/or by adjusting process throughput. Process planners, parts programmers, production floor managers and operators all tend to select conservative metal removal rates (i.e., feedrates, speeds, depth) which, in turn, reduce machine tools' overall productivity. With today's requirements for higher speeds, lighter weights, smaller tolerances, and greater process flexibility and efficiency, traditional approaches make precision requirements to an accuracy of less than one ten thousandth of an inch. The combination of laser radar techniques coupled with fiber optics would allow a rugged and compact system to be assembled to measure, in real-time, the amplitude of vibration in the machining process. Furthermore, the use of fiber optics makes it possible to measure vibrations at multiple stations or locations with one compact system.

PHASE I: Will investigate using laser radar and fiber optics as a viable approach to monitoring vibrations at multiple locations. The goal of this Phase I effort will be a proof of concept system demonstrating the capability of accurately measuring vibration.

PHASE II: Will build upon the Phase I work to a) design a robust, reliable and maintainable prototype system, b) fabricate the prototype system, and c) validate the prototype system by measuring vibration at a minimum of five machine tool stations nearly simultaneously. The prototype system will be capable of being integrated into an existing machine tool environment.

PHASE III DUAL USE APPLICATIONS: The results of this program will provide vibration measurement and machine tool control for both Government and commercial applications. Other potential applications are aircraft vibration measurement, precision coordinate measurement, rapid prototyping and structural vibration analysis.

REFERENCE:. "Laser Vibration Sensing," Kachelmyer, Alan L. and Schultz, Kenneth I. Journal Info: The Lincoln Laboratory Journal, Sprg 1995 v 8 n 1.

KEYWORDS: Laser radar, Fiber optics, Machine tool control, Vibration measurement

AF99-154 TITLE: Web-based Process Design Agents

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Capture interactions between disciplines and organizations, and therein, interdisciplinary relationships which enable collaborative engineering pursuits involving cost versus performance.

DESCRIPTION: A web-based cross-platform design environment, in a performance-based marketplace will facilitate profound changes on the design process - as we know it. Fundamental to that change is the perceived exponential growth in participants, not only from various disciplines within an organization or company, but up and down the multi-tiered supply chain - all of whom will have the opportunity to converge and engage each other on problems and solutions. The raw speed and potential voracity of such a global - 24 hour/day - design environment, given the undetered access by all who wish to participate, will be without precedence, and indeed, a paradigm shift in need of work-flow scheduling and dependency-tracking.
Few would argue that much remains to be learned regarding the process of design or re-design regarding spares production. We are told that design, as a process, is an expertise which is acquired through years of experience, and inspite of sundry efforts, little is known of what is truly generic, and thus universal, in support of a science. Given the formidable data gathering problems associated with capturing salient design knowledge across a diverse set of applications, cultures, etc., and the frustrations which surround issues such as the protection of intellectual property, a web-based design environment affords an opportunity to overcome these obstacles and exploit a technology referred to as agents to efficaciously gather, organize, compare and classify activities, sequences, information and their types, and potentially afford us needed expertise in the form of a video - simulation of the ideal process for our design problem.

PHASE I: Demonstrate the feasibility of pattern formation capability across a broad range of product and/or process designs ranging from bulk materials for structures to multi-layer thin-film interfaces, i.e., inter-layer and film-to-substrate, for tribological, temperature/oxidation resistance and electro-optical coatings. Materials of immediate interest are for performance enhancement and/or sustainment of aging aircraft to include high temperature intermetallics, composites, and inorganic electro-optical materials.

PHASE II:Develop a generic capability for near real-time monitoring and pattern formation across a broad range of component design materials and processes (defense and commercial) and demonstrate the discovery of patterns which suggest preferred methods, sequences and disciplines which optimize design cost and quality.

PHASE III DUAL USE APPLICATIONS: Dual use of this exploratory research is foreseen for the design of systems, more specifically, complex systems for automotive, aircraft, and/or space.

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2. Anand, S., Bell, D., Hughes, J., EDM: A general framework for Data Mining based on Evidence Theory, Data Knowledge and Knowledge Engineering, Apr 1996.
3. Heckerman, D., Bayesian Networks for Data Mining, Data Mining and Knowledge Discovery, Vol. 1 Issue 1, March 1997.

KEYWORDS: Design, Process, Materials, Autonomous Agents, Pattern Formation

AF99-155 TITLE: Advanced Resin System for RTM/VARTM Processing

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: To develop a low temperature cure resin system tailored for Resin Transfer Molding (RTM) and Vacuum Assisted Resin Transfer Molding (VARTM)

DESCRIPTION: RTM and VARTM processing of composite parts have been implemented on numerous commercial and military contracts; however, current applications are based on resin systems that cure at 350F and have service temperatures in the 250-350F range. While this is good enough for many applications, the full benefits of RTM/VARTM will not be realized without resins more tailored to the processes. Resin systems are needed that have low viscosity at room temperature for infusion, low cure temperatures (<180F) for low cost tooling applications, and freestanding post cures for E-beam or non-autoclave curing. This topic will support the Composites Affordability Initiative (CAI), a government/industry team focused on developing the tools and technologies necessary to enable future innovative designs for composite aircraft.

PHASE I: Develop a promising resin system using current aerospace resin systems as a baseline. Preliminary investigations should include viscosity data, curing data, post cure data, and initial data on process repeatability. Coupons will be fabricated and tested as to determine their potential towards topic resolution.

PHASE II:Further develop the resin system and demonstrate it on a military aerospace application. Data will be collected to further characterize the resin system. Both E-beam and oven post cure methods will be demonstrated during the Phase II effort.

PHASE III DUAL USE APPLICATIONS: The developed resin system will have military applications for processing of advanced composite aerospace components as well as other applications for land and sea based military craft. There is also a large commercial base in the areas of marine craft, recreational equipment, automotive, transportation, and various other markets that currently use composite RTM structures.

REFERENCES:
1. Composites Affordability Initiative Overview, (web site or DTIC white paper to be added).
2. Binetruy, C.; Hilaire, B.; and Pabiot, J (1998), "Tow Impregnation Model and Void Formulation Mechanisms during RTM." Journal of Composite Materials, Vol. 32, 223-245.
3. Lebrun, G.; Gauvin, R; and Kendall, K. N. (1996), "Experimental Investigation of Resin Temperature during Filling and Curing in Epoxy and Nickel Shell RTM Molds." Journal of Materials Processing & Manufacturing, Vol. 5, 27-44.

KEYWORDS: Resin, Curing, Processing, Composites, Vacuum Assisted RTM (VARTM), Resin Transfer Molding (RTM)

AF99-156 TITLE: Gate-All-Around SOI for Space Applications

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Develop a gate-all-around (GAA) silicon on insulator (SOI) process compatible with conventional complimentary metal-oxide semiconductor (CMOS) processing.

DESCRIPTION: The gate-all-around (GAA) SOI MOSFET (metal-oxide semiconductor field effect transistor) is a MOS (metal-oxide semiconductor) device completely surrounded by its gate. The performance of the GAA SOI MOSFET is improved relative to a conventional bulk or SOI MOSFET due to its increased active surface area, and thus greater transconductance. In addition, elimination of the back interface greatly improves the total dose radiation hardness of SOI MOSFET's by eliminating any leakage current path between source and drain. Latchup is not an issue in SOI circuits because of the ideal device isolation, and single-event upset is reduced due to the reduced collection volume beneath the source and drain. Thus the GAA SOI technology should be ideal

for space applications. A GAA structure can be manufactured by forming a gate pattern in polysilicon over an SOI wafer, then overcoating the wafer with an insulator, planarizing the insulator, flipping and bonding the insulator to another wafer, stripping the underlying substrate from the original wafer, and completing the top gate and metal layers using a conventional CMOS process. The objective of this project is to develop a cost effective, reliable GAA SOI MOSFET integrated circuit manufacturing process suitable to produce space qualified hardware.

PHASE I: Develop a bottom gate formation and wafer bonding technique and combine with a conventional CMOS process to form a GAA SOI process. Produce a basic/prototype GAA SOI device and demonstrate operability in a "non-space" environment.

PHASE II:Finalize the Phase I GAA SOI production process. Fabricate (mutually agreed) production prototype GAA SOI devices. Demonstrate the capabilities/radiation hardness of the GAA SOI process by performing qualification testing, including total-dose, single-event upset, and latchup, on the production prototype structures.

PHASE III DUAL USE APPLICATIONS: The GAA SOI process will enhance the speed performance and reduce the leakage currents of all SOI technologies, military, space, and commercial. The low leakage currents and high speed of the GAA technique will have special importance for SOI dynamic random access memories, (DRAM's).

REFERENCES:

1. J.P. Colinge et al., Silicon-on-Insulator Gate-All-Around Device, IEDM Tech. Dig., pp. 595-598, 1990.
2. P. Francis et al., Temporal Analysis of SEU in SOI/GAA SRAMs, IEEE Trans. Nuc. Sci, 42, 2127 (1995).
3. D.C. Mayer and K.P. MacWilliams, Silicon-on-Insulator Gate-All-Around MOSFET Devices and Fabrication Methods, US Patent No. 5, 497,019, March 1996.

KEYWORDS: CMOS, MOSFET, Gate-All-Around, Transconductance, Radiation Tolerant, Silicon-on-Insulator

AF99-157 TITLE: Singularity/Boundary Layer Approach for Composite Joints with Discrete Damage

TECHNOLOGY AREA: Materials, Processes and Structures

OBJECTIVE: Development of a 3-D singularity/boundary layer analysis tool for bolted/bonded composite joints with discrete cracks.

DESCRIPTION: The analyses of composite bolted joints and bonded joints present some of the most important and difficult tasks confronting designers of advanced airframes. In collaboration with a number of prominent airframe manufacturers, the Structural Materials Branch (WL/MLBC) of the Materials Directorate, AF Research Laboratory is engaged in a program to improve the stress analysis of bolted and bonded composite joints. The novel method to be developed for the present SBIR effort shall potentially offer more speed and flexibility in modeling joints of complex geometries, for structural engineering applications, than is possible using present methods. The required analyses for both phases shall be limited to linear elastic material responses. Although the critical phenomena to be modeled are localized, the software must produce accurate, full-field solutions over the entire domain.

It is strongly recommended that the proposal include graphical representations of the stress solutions of a boundary value problem involving at least two discrete elastic layers of dissimilar properties. Incorporation of singular behavior is encouraged. The solutions must be obtained using a novel numerical method. Methods already recognized as established engineering tools will not be viable candidates.

PHASE I: Development expertise shall be demonstrated by obtaining the solutions of difficult boundary value problems in layered elasticity, involving such features as free edges, cracks, and possibly 3-D fields. Layers and cracks shall be modeled discretely. The contractor shall, in addition, demonstrate the capability of generalizing the method to 3-D analyses of laminated bodies having anisotropic layers, interacting cracks and arbitrary geometries, according to the Phase II criteria stated below.

PHASE II: A 3-D analysis method meeting all of the criteria stated below shall be developed, and the solutions and computer code shall be made available to the Air Force and other DoD organizations. The computer program shall meet the following requirements:

1. The 3-D stresses and strains at arbitrarily specified points and the potential and strain energies of the body are the required outputs.
2. Joints are constructed of laminated composite materials; each lamina shall be discretely modeled, i.e., modeling using effective laminate properties is not permitted.
3. Bolted joints shall include a countersunk bolt-loaded hole with clamping stresses; elastic deformation of the bolt shall be treated and the contact zones shall be correctly evaluated.
4. Multiple, interacting cracks shall be included as discrete traction-free surfaces.
5. The program shall be readily adaptable to arbitrary geometries and loadings.
6. The program shall be implemented on a deskside-type workstation and have an execution time practical for engineering designers in the field, for laminates comprised of no fewer than 30 plies of arbitrary orientations.

PHASE III DUAL USE APPLICATIONS: The potential exists for a user-friendly, interactive computer code that can accurately predict progressive damage and failure of composite bolted joints of arbitrary geometries, and can aid in load-carrying assessments of bonded joints. As conceived, the end product will be a powerful analysis tool with wide applicability and high demand in the commercial and military aerospace industries, as well as in other industries where composites are utilized, such as automotive, power generation, marine and sporting goods.

REFERENCES:

1. Lund, J. and Bowers, K. L. (1992), Sinc Methods for Quadrature and Differential Equations, SIAM, Philadelphia.
2. Stenger, F. (1993), Numerical Methods Based on Sinc and Analytic Functions, Springer-Verlag, New York.

KEYWORDS: Singularity, Boundary layer, 3-D stress, Bolted joints, Bonded joints, Composite material

AF99-158 TITLE: Electrically Conductive, Optically Transparent Polymeric Coating for Canopy ESD Protection

TECHNOLOGY AREA: Materials, Processes and Structures

OBJECTIVE: Design, synthesize, and develop novel transparent conductive organic polymeric materials to be processed in monolayer film by state-of-the-art methods for aircraft canopy electrostatic charge dissipation (ESD).

DESCRIPTION: Electrostatic charge build-up caused by frictional as well as static forces upon state-of-the-art canopy substrate materials has caused considerable documented damage to coated, laminated canopies. Current ESD materials possess acceptable static conductivities but suffer from lack of physical integrity and mechanical robustness in thin film form. Organic polymers may provide that mechanical integrity for the conductive coating. Organic polymers are also more similar to the substrate plastics in chemical composition or can be tailored by the addition of functional chemical groups to be more like the substrates so that adhesion is improved. Expertise is sought for the preparation and pertinent testing of novel conductive monolayer organic polymer compositions which are compatible with current canopy substrate materials and are electrically continuous, thermooxidatively stable, and durable (i.e., environmentally stable, mechanically robust). Previous canopy efforts have focused on blends of known conducting polymers, such as polyaniline, in an effort to form a composite film. Recent scientific advances, however, have demonstrated by atomic force microscopy that truly monolayer (one molecule thick) films of conductive polymers can be formed on glass and silicon substrates, and that such films are electrically contiguous. Some monolayer films have been shown to be so mechanically robust that they cannot be removed from the substrates even with vigorous mechanical force. The aim of this solicitation is to develop this discovery further toward application on aircraft canopies. Anticipated advantages of this technology would be little or no degradation in overall canopy optical performances and no measurable additional weight to the canopy - both of which are anticipated natural consequences of the coatings being only one molecule thick.

PHASE I: The goals of the Phase I effort shall include the preparation of novel aromatic or heteroaromatic polymers with direct current (DC) surface conductivities in the range of 10-5 to 10-8 S/cm as monolayer (one molecule thick) films measured by four-point probe, van der Pauw or other similar methods. The ability to prepare the monolayer by an accepted low temperature coating method such as sol-gel, Langmuir-Blodgett, or other flowcoating techniques will greatly reduce the costs of processing the final polymer composition and accelerate the technical transition of the candidate material. The methods by which to evaluate the successful conductive monolayer candidate include the test methods previously cited, determination of coating profile on substrates, differential scanning calorimetry and thermogravimetric analysis for basic polymer thermoanalytical properties, and characterization of basic physical properties of the polymer by determination of molecular weight and solution viscosity. A key element of Phase I includes the demonstration that electrically contiguous monolayer films can be formed on polycarbonate substrates.

PHASE II: In Phase II of the effort the technical work shall require the preparation of up to 450 grams of polymer under reproducible conditions based on the technology developed in Phase I. Evaluation of the optical quality and durability of the processed materials shall involve tests such as QUV; luminous transmittance, haze, and yellowness index although it is anticipated that optical quality will not be a major issue if true monolayers are obtained. Chemistries and processes shall be developed to maximize mechanical robustness as measured by standardized ASTM abrasion tests on various substrates and solvent crazing under load. Full thermoanalytical, thermomechanical and rheological characterization shall also be required. Deliverables of the candidate polymer on 2 ft2 X « inch thick optical grade polycarbonate sheet shall be required at the conclusion of the Phase II effort.

PHASE III DUAL USE APPLICATIONS: Dual use potential exists for the successful composition and process that optimizes low production cost. Commercial applications would include ESD coatings for minimizing charge build-up on transparencies in bead blast booths that are used to remove conformal coatings from electronic boards and ESD coatings for minimization of tribocharging on television and computer CRT screens.

REFERENCES:
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3. V. G. Kulkarni, Proceedings: Conf. Plast. For Portable and Wireless Electronics, Soc. Plast. Eng., 18 (1997).
4. V. G. Kulkarni et al., Elect. Overstress/Electrostatic Discharge Symp. Proc., 225 (1995).

KEYWORDS: Aircraft transparencies, conductive polymers, electrostatic discharge, monolayer, flowcoat, films.

AF99-159 TITLE: Lubrication in Extreme Environments

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop lubrication systems capable of operating for long periods of time in extreme (hostile) environments.

DESCRIPTION: Air Force systems are required to operate in hostile environments for increasing time periods. They are expected to have long life and consistently provide high performance. Materials are under development to meet some of these needs, but lubrication and wear control technology are lagging behind. This topic is focused on addressing these lubrication issues. Miniaturization of components and functions is of critical importance as the AF increasingly relies on space borne systems and unmanned air vehicles. Microelectromechanical systems (MEMS) hold the potential for significant advancements in these areas as well as providing a sensor capability for health monitoring, which will extend lifetime and reduce life cycle costs by permitting a move toward "as needed" as opposed to "scheduled" maintenance. Specific devices incorporating MEMS include motors, gyros, microwave switches, phased arrays, etc., as well as a variety of sensors including optical, chemical, electronic, etc.. However, friction and wear problems prevent the realization of some MEMS devices and reduce the performance of others. MEMS devices present one of the most challenging hostile environments because they are processed and packaged similar to semiconductors. Proposals on new materials, coatings, and surface treatments (e.g., self-assembled monolayers) for lubrication and wear control of MEMS devices are sought. Turbine engine environments are also hostile; engines are required to operate at increasingly higher temperatures to improve aircraft efficiency and performance. Oils that operate above 288 C without undergoing significant coking or degradation are not available. Perfluoropolyalkylethers are good candidates, but they degrade at high temperature in the presence of metal alloys, particularly those containing iron. The degradation products attack the alloys, thus destroying the lubrication system. Ceramic systems are also degraded. Proposals using a systems approach (considering the bearing balls, races, cages, corrosion resistant coatings, surface treatments, lubricants and performance enhancing additives) are encouraged.

PHASE I: Develop a viable approach and determine the materials and/or materials combinations to address the key elements of one of the research and development areas described above .

PHASE II:Follow-on efforts in Phase II will further develop and optimize the materials, coatings, surface treatments, and/or complete lubrication systems using the approaches established in Phase I.

PHASE III DUAL USE APPLICATIONS: The materials and technology developed under this program would have numerous dual use applications. The commercial aircraft and spacecraft industries will benefit because the technology developed will be directly applicable to their needs for reduced size and weight. Any industry in which miniaturization is important, or that uses sensors in a critical application may also benefit.

REFERENCES:
1. "Microelectromechanical Systems: Advanced Materials and Fabrication Methods," NMAB-483, National Academy Press, Washington, DC 1997.
2. "Advanced Hard Coatings and Wear Resistant Materials for Aerospace Systems," J.S. Zabinski, A.A. Voevodin, and M.A. Capano, AGARD-CP-589, 1996. [ADA 318971 (Article 4)-NTIS]
3. "Soluble Additives for Perfluoropolyalkylether Liquid Lubricants," Lubrication Eng., V49, 702-708 (1993).

KEYWORDS: Oils, Coatings, Lubricants, Surface treatments, Lubricant additives, Self-assembled monolayers, Lubricated spacecraft mechanisms, Microelectromechanical systems (MEMS)

AF99-160 TITLE: Carbon-Reinforced Composites for 550 to 1200 degrees F Applications

TECHNOLOGY AREA: Materials, Processes and Structures

OBJECTIVE: To develop affordable carbon-reinforced polymer (PMC) or carbon (C-C) matrix composite materials and processes for 550 to 1200øF applications.

DESCRIPTION: The Air Force is seeking new and highly innovative concepts for affordable processing approaches and materials for carbon-reinforced PMC and C-C. Current and future Air Force applications require high temperature performance in the range of 550 to 1200°F with oxidation and chemical stability of 1000 hours. These applications include: aircraft and launch vehicle engine components; aircraft primary structures, engine cells, environmental heat exchangers, and other thermal management systems. Titanium is typically used for these applications because it is lightweight, exhibits good structural properties and is reasonably corrosion resistant. Other materials include INCONEL , which are heavy and moderately expensive. Before a composite part could replace a titanium or INCONEL part, processing costs and starting material's cost must be reduced. Therefore, innovative concepts utilizing lower cost materials, with the objective of reducing life cycle material cost by an order of magnitude, lower cost high conductivity fibers, improved oxidation resistant systems and high temperature bagging and sealants are solicited. These materials must be suitable with low cost processing technologies such as, resin transfer molding (RTM), vacuum-assisted resin transfer molding (VARTM), tow placement, near net shape or one-step manufacturing. This temperature range is not inclusive for all applications, i.e., some may require 550-800°F while others may need 1000-1200°F materials. The specific application requirements will define the type of composite matrix that will be required, i.e.; the lower temperature will probably utilize a polymer matrix composite while the higher temperatures will demand a carbon matrix. But regardless of the matrix material, the composite component must be affordable and easily processed compared to the titanium or INCONEL part to be replaced.

PHASE I: The Phase I program must demonstrate the feasibility and cost savings of the proposed concept for the PMC or C-C sufficient to justify further development and/or scale-up in a Phase II effort. Proof-of-concept includes demonstration of oxidation/chemical stability and/or processability of specimens or small sub-components. In addition, the materials shall be evaluated to prove they can meet the specific properties of titanium or INCONEL in an equivalent service environment.

PHASE II: The concepts demonstrated in Phase I will be scaled up and developed in detail. The payoffs and benefits of the technology will be demonstrated by fabrication, processing and characterization of a component or subcomponent.

PHASE III DUAL USE APPLICATIONS: A variety of aircraft, spacecraft and launch vehicle applications (commercial and DOD) use high temperature structural materials. Demonstration of a lighter weight, lower cost alternative would provide tremendous savings for aircraft heat exchangers, aircraft and launch vehicle engine components, aircraft fuselage, wing and tail structures, as well as engine cells.

REFERENCES: G. Savage, "Carbon-Carbon Composites", Chapman & Hall, 1993. 43rd International SAMPE Symposium, Anaheim CA, 1998. 42nd International SAMPE Symposium, Anaheim CA, 1997.

KEYWORDS: 550 to 1200øF composites, high temperature bagging and sealant materials, affordable resins and processing, oxidation/chemical stability, polymer matrix composites, carbon-carbon composites.

AF99-161 TITLE: Epitaxial Growth of Silicon Carbide (SiC)

TECHNOLOGY AREA: Materials, Processes and Structures

OBJECTIVE: Develop advanced, innovative epitaxial processes for the growth of silicon carbide for electronic applications.

DESCRIPTION: Advanced Air Force systems will require new and novel semiconducting materials to meet challenging power, frequency, speed, and temperature requirements. Conventional semiconductors such as bulk silicon and gallium arsenide cannot meet these requirements. Silicon carbide has many unique properties such as wide band gap, high breakdown field and physical strength, which make it attractive for high temperature and high power applications. This task seeks to develop improved and innovative approaches for the growth of single crystal epitaxial silicon carbide. Homoepitaxy of 6H- and 4H-SiC are of primary interest, however heteroepitaxy of other SiC polytypes on SiC substrates will be considered. Amorphous SiC and SiC-on-silicon will not be considered under this solicitation. Growth of SiC for protective or thermal coatings or other surfaces such as mirrors is not considered applicable to this topic. Projects that are primarily device development or device processing will also be considered nonresponsive.

PHASE I: Phase I will address process development and initial testing to show proof of concept. Phase I goals shall include confirmed homo- and/or heteroepitaxial growth. Additionally, epitaxial thickness and thickness variation goals for Phase I shall be commensurate with ultimate requirements for future device and electronic structures development. Modeling studies of growth processes or materials properties are appropriate. A deliverable of a representative test sample to the government is encouraged.

PHASE II: Phase II will develop the advanced semiconducting materials and/or processes to demonstrate the potential application. Phase II goals shall reflect state-of-the-art parameters for epitaxial growth including but not limited to total epitaxial thickness variation of less than 2% across growth substrate and, if applicable, total doping concentration variations less than 2% across growth substrate. Additionally, a goal for total epitaxial macroscopic defects shall be less than 1 per square centimeter.

Modeling studies of growth processes or materials properties are appropriate. Deliverables of test materials to the government for evaluation are encouraged.

PHASE III DUAL USE APPLICATIONS: Microwave devices made from SiC will exhibit high power, high frequency operation (e.g. 20 watts in X-band at room temperature) with higher package density and reduced cooling subsystem requirements. In addition, the high temperature nature of SiC permits the development of a host of harsh environment electronic devices. SiC electronics have many commercial applications. The automotive industry needs reliable materials and devices for the high temperature, corrosive, dirty environment in an automotive engine. Additionally, one of the planned uses in military aircraft, namely, on-engine flame detectors (i.e. in the engine during flight) is directly transferable to civilian aircraft. The development of improved epitaxial growth processes for SiC will be required to successfully commercialize these high temperature, high power devices.

REFERENCE: "Mechanical Properties of Semiconductors and Their Alloys," SRI Inc, AD No: A231820.

KEYWORDS: Silicon Carbide, Materials, Epitaxy, Crystal Growth

AF99-162 TITLE: High-Efficiency Dynamic Holographic Materials

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop new materials having real-time holography applications.

DESCRIPTION: High efficiency dynamic holographic materials (HEDHM) are optical materials having application in real-time holography. A HEDHM material contains photochromic dyes that undergo large birefringence changes upon irradiation. A grating written on this material has high hologram efficiency. Unlike static holograms, dynamic holograms decay with a user-defined half-life varying from seconds to hours. Therefore, HEDHMs have application in optically switchable reflection holography, schlerien optics, spatial light modulators and optical data storage. An example of a potential HEDHM is the photochromic polypeptide, which undergoes light-induced coil to helix transition followed by dark adaptation. If the polypeptide has a monodisperse molecular weight distribution, higher grating efficiency is possible through the greater ordering of the material. A second example is bacteriorhodopsin. Bacteriorhodopsin has been used in real-time holography, although the efficiency is low. If the hologram efficiency can be raised, the utility of bacteriorhodopisin would increase. A third example combines photochromism and liquid crystal optics. For laser protection, HEDHMs would be used as an optically switchable holographic mirror where an unknown threat laser would write a holographic mirror, thereby reflecting the light. When the threat is inactive, the mirror would decay. Proposals submitted to this topic should clearly address the applications where this device technology could be applied; however, the content of the program should focus on materials and process development - not device demonstration.

PHASE I: During this phase the offeror will demonstrate the feasibility of the materials or processes to give a proof of principle and identify those materials/processes issues which must be addressed during Phase II of the program.

PHASE II:Optimize the materials and/or processes to achieve performance or capabilities not currently available. Design, fabricate and characterize a test article based on the developed materials or processes which demonstrate an advance in the state of the art in real-time holography.

PHASE III DUAL USE APPLICATIONS: Holographic materials have numerous commercial applications. Examples of applications for high efficiency dynamic holographic materials include display technology, optical data storage and spatial light modulators.

REFERENCES:
1. Cooper, T.M. Mol. Cryst. Liq. Cryst. 298: 197-203(1997).
2. Cooper, T.M., Natarajan, L.V. Trends. Polym. Sci. 1: 400-405(1993).

KEYWORDS: Holography, Photochromism, Dynamic Holography, Holographic Materials, Photochromic Polymers, Photochromic Polypeptides

AF99-163 TITLE: Materials for Superlattice Infrared Detectors

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Research and development of innovative epitaxial growth techniques for III-V superlattice materials with controlled mixed anion interfaces.

DESCRIPTION: The Air Force requires new very long wavelength infrared (VLWIR) detectors with increased operating temperature and improved detectivity for space based applications. These detectors will be required to operate over a wide range of wavelengths including those beyond 16 micrometers. The presently available detectors are extrinsic silicon. Due to excessive dark current, the operating temperature of these detectors is below 20K. Detectors with increased operating temperatures with equivalent or better detectivity will have significantly reduced launch costs due to reductions in the weight of the cryocooler. The principal alternatives to extrinsic silicon at present are compound semiconductor superlattices based on group III antimonides and arsenides. Detector structures have been fabricated from InGaSb/InAs and InAsSb/InSb superlattices but the performance has not been adequate. This task seeks to develop improved and innovative epitaxial growth techniques for growing superlattices based on mixed anion interfaces such as InGaSb/InAs. Both molecular beam epitaxy (MBE) and metal organic chemical vapor deposition (MOCVD) will be considered as well as other novel growth techniques. It is expected that improvements will be made in interface purity, abruptness and smoothness. Growth on novel substrates is encouraged.

PHASE I: Phase I will address process development and growth of simple heterointerfaces along with the minimum characterization to demonstrate improved interfaces. A deliverable of a representative test sample to the government is encouraged.

PHASE II:Phase II will optimize the growth process demonstrated in Phase I with more extensive characterization. Modeling of the growth process or superlattice properties are appropriate. Growth and evaluation of superlattice structures suitable for VLWIR detectors will be used to demonstrate the success of the program. Delivery of test materials to the government for evaluation is encouraged.

PHASE III DUAL USE APPLICATIONS: Structures based on mixed anion heterointerfaces have applications in a wide variety of electronic and opto-electronic areas. In particular, room temperature operating infrared detectors based on III-V semiconductor superlattices or multiple quantum wells are of interest to the automotive and aviation industries, among others. Microwave transistors based on mixed anion heterointerfaces have application in many commercial areas such as cellular phones, and direct broadcast satellite television.

REFERENCE: J. L. Johnson, L. A. Samoska, A. C. Gossard, J. L. Merz, M. D. M. Jack, G. R. Chapman, B. A. Baumgratza, K. Kosai, and S. M. Johnson, Journal of Applied Physics Vol. 80, Pg. 1116 (1996).

KEYWORDS: Epitaxy, Infrared, Materials, Superlattice, Semiconductor, Hetero-Interfaces

AF99-164 TITLE: Absorbing Dyes with Improved Properties

TECHNOLOGY AREA: Sensors

OBJECTIVE: Synthesize injection moldable dyes with enhanced performance, large extinction coefficients, narrow spectral bandwidths, with improved performance and utility for laser eye protection applications.

DESCRIPTION: Laser eye protection devices are based upon a variety of absorbing and reflecting technologies that provide control of energy reaching the eye. There is a continuing need for cost effective alternatives to reflective technologies such as dyes that absorb energy at selective wavelengths. Additionally, for reflecting technologies that are becoming more affordable and ubiquitous, dyes are used, individually or in combination, to manage narcissistic back reflections. There is a need for dyes that can provide high attenuation to specific wavelengths, higher transmittance off peak absorption and greater robustness to environmental variables such as manufacturing processing conditions. The technological shortfalls preventing wider implementation of dye based eye protection includes; poor UV stability; degradation at elevated injection molding processing temperatures; fluorescence; and reversible bleaching effects at high irradiation levels. The objective of this topic is to synthesize new dyes with symmetrical absorption profiles with very low off-peak absorption, no satellite peaks and no Soret absorption bands are desirable. Examples of research and development efforts appropriate to this topic are 1) the synthesis and incorporation into polycarbonate and 2) evaluation of one or more new dyes that overcome the deficiencies noted with properties such as those in table 1.

Table 1. Materials Research Goals for Synthesized Dyes

Wavelengths of Interest(nm)	Extinction Coefficient	Bandwidth FWHM @ OD=2	Temperature Stability	Luminous Transmittance
500, 532, 560, 590, 694	|50000	£20nm	485 F and 565 F	| 75%
1300	|50000	>50 nm	485 F and 565 F	| 75%

The full width half maximum bandwidth applies for a peak OD=3.

Proposals submitted to this topic must clearly address the end item application for which the dyes are used, the interaction of process variables involved and provide example dye/host material witness samples. The emphasis, however, is on synthesis and characterization of one or more dyes with improved performance.

PHASE I: During this phase, the offerer will demonstrate the feasibility of synthesizing one or more of the materials (dye in host), and identify those issues which must be addressed during Phase II of the program.

PHASE II: Optimize the dye(s) using Table 1 values as requirements. Design and deliver characterized prototype protective devices in ophthalmic quality lens spectacle format and in ophthalmic quality visor format based upon improved dyes. Demonstrate producibility through pilot level production of 200 lens blanks and 100 visors.

PHASE III DUAL USE APPLICATIONS: Laser eye protective devices are required for a wide variety of laboratory and military personnel protection applications.

KEYWORDS: Porphyrins, Dithiolenes, Polycarbonate, Absorbing dyes, Optical filters, Injection molding, Phthaloalocyanines, Laser eye protection

AF99-165 TITLE: SOI Material for High Reliability Space Systems

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop an SOI screening methodology that will enable highly reliable gate oxides in SOI microcircuits.

DESCRIPTION: The development of SOI (silicon on insulator) technology and its incorporation into space systems has been hampered by unacceptably poor gate oxide integrity caused by defects, impurities, and surface roughness in the starting SOI material. These defects can reduce the yield and subsequent reliability of integrated circuits manufactured using SOI materials. A methodology/technology for early quantitative detection/evaluation of SOI failure related material characteristics is required. An analytical material evaluation process will support the improvement of SOI starting material quality and facilitate evaluation of the reliability of very thin gate oxides (grown on variously constructed SOI films) as a function of the defect types that generate the observed oxide failures.

PHASE I: In this phase, a test methodology will be developed that will quantitatively assess the quality and reliability of gate oxides grown on silicon-on-insulator films. The methodology shall be demonstrated through data obtained by growing and stressing thin oxides on SOI films to failure by conventional time-dependent dielectric breakdown techniques, and characterizing the resulting failure sites as (among others) defect-, roughness-, or contaminant-related.

PHASE II:In this phase, the test methodology shall be finalized, test equipment necessary to implement the technique will be procured/constructed and the methodology shall be statistically validated by sufficient data (similar to the data described in Phase I supplied through Air Force assistance.

PHASE III DUAL USE APPLICATIONS: The gate oxide stress measurement technique can be applied to SOI starting material for both space qualified military and commercial SOI products. This technique will enable the widespread usage of SOI material for all applications, including space as well as ground-based systems. Current commercial suppliers of SOI products have evidenced high interest in development of this technology.

REFERENCES:

1. S.Q. Hong et al., Integrity of Gate Oxide on TFSOI Materials, in Proceedings 1995 IEEE Int. SOI Conf., Oct. 1995, pp. 22-23.
2. S.R. Wilson et al., Materials, Device and Gate Oxide Integrity Evaluation of SIMOX and Bonded SOI Wafers, in Proceedings 1995 IEEE Int. SOI Conf., Oct. 1995, pp. 143-145.
3. G. Brown et al., Integrity of Gate Oxides Formed on SIMOX Wafers, in Proceedings 1994 IEEE Int. SOI Conf., Oct. 1994, pp. 73-74.

KEYWORDS: SOI, silicon, insulator, gate oxides

AF99-166 TITLE: Frequency Conversion and Electro-Optical Materials

TECHNOLOGY AREA: Materials, Processes and Structures

OBJECTIVE: Develop new nonlinear optical materials with superior properties as compared to those presently available.

DESCRIPTION: Nonlinear optical (NLO) materials are required for a variety of Air Force appli-cations including infrared countermeasures, remote sensing of chemical and biological agents, optical communications, and optical interconnects. These applications require new laser sources (optical parametric oscillators and harmonic genera-tors) and electro-optic devices (directional couplers, guided-wave interferometers, and optical phase shifters). However, presently available materials are unsatisfactory for

many applications due to small nonlinearities, poor optical clarity, difficulty in process-ing for devices, vulnerability to environmental degradation, and other factors. Proposed efforts shall address inorganic or organic materials in bulk or thin-film forms, which exhibit large second-order nonlinear effects. Strongest interest is (1) in bulk crystals eventually capable of handling average output powers greater than 10 watts for frequency conversion to the 2- to 12-micron wavelength range and (2) in thin films for guided-wave devices in the 0.7- to 1.55-micron range. Innovative tech-niques for preparing new materials are encouraged. Currently available materials such as periodically-poled lithium niobate (PPLN) are outside the scope of this topic. Nonlinear optical devices may be examined only as a minor part of a materials effort to evaluate and demonstrate the properties of the material(s).

PHASE I: The objective is to demonstrate a new material, the feasibility of a proposed new growth technique, improved functionality of a material through innovative processing techniques, or improved materials properties resulting from either growth or processing advancements.

PHASE II: The objective is to further develop the proposed material and / or the relevant processes to fully demonstrate the materials properties and usefulness for commercial and military applications. Establish all necessary manufacturing processes for commercialization of a product.

PHASE III DUAL USE APPLICATIONS: Materials technology is fundamental to all applications, military and commercial. Examples of commercial applications for NLO bulk crystals are LIDAR for environmental monitoring, medical lasers, and scientific instruments. Examples for NLO thin films are optical switches for cable TV, optical phase shifters for phased array radar; optical interconnects for electronic packages, and switching networks for communications.

REFERENCES:

1. Bordui, Peter F. and Martin M. Fejer, "Inorganic Crystals for Nonlinear Optical Frequency Conversion," Annual Review of Materials Science (Volume 23), ed. Robert A. Laudise et al, Annual Reviews Inc, 1993

2. Dmitriev, V.G. , G.G. Gurzadyan, and D.N. Nikogosyan, Handbook of Nonlinear Optical Crystals 2nd Edition, Springer-Verlag, 1997.

3. Baumgartner, R.A. and R.L. Byer, "Optical Parametric Amplification," IEEE Journal of Quantum Electronics QE-15 (1979), pp. 432-444.

4. Lackritz, Hilary S. and John M. Torkelson, "Polymer Physics of Poled Polymers for Second-Order Nonlinear Optics," Molecular Nonlinear Optics. Academic Press, 1994.

5. Ghosh, Gorachand, Handbook of Thermo-Optic Coefficients of Optical Materials with Applications, Academic Press, 1998.

KEYWORDS: Nonlinear optical materials, NLO materials, electro-optic materials, optical signal processing, second harmonic generation, optical parametric oscillation, Pockels effect.

AF99-167 TITLE: Novel, Self-Cleaning Filter for Carbonaceous PM2.5 in Combustion Exhausts

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Develop and demonstrate a cost-effective technology that will remove soot from hot gas streams and convert it into environmentally benign products.

DESCRIPTION: Revisions to NAAQS being imposed under Title I of the Clean Air Act will require the application of effective measures to decrease tailpipe and stack emissions of combustion-derived particulate matter (soot). Modifications to the combustion process are expected to provide part of the solution, but options for effective, affordable control, which are the target of this solicitation, are also expected to be needed. The technology must be capable of extended (months) periods of unattended operation in a nonconstant operating environment, and (to allow for application to mobile systems) should fit within the dimensions of typical combustion sources that it is sized to control. Introduction of hazardous materials, use of high-tech methods, and loss plus consumption of more than 2% of the total power output of the source will be considered negative factors in selection.

PHASE I: Develop and conduct a bench-scale demonstration of the technical principle(s) upon which the control strategy is dependent. Perform a preliminary analysis of the estimated cost to apply the technology to one or more candidate sources. Develop a commercialization plan, identifying any partners and other resources.

PHASE II:After additional development, assemble and test a pilot-scale engineering model of the technology in a controlled environment. After any necessary modifications and adjustments, test the performance of the pilot system on an actual source (or a split of the exhaust from an actual source) at an operational site to be agreed upon with the POC. The test will include measurement of performance, treatment by-products, consumption of any added materials, energy usage, operator time, and any other factors contributing to costs. Data from the test will be used to perform a more-refined analysis of the cost of applying the technology to several general cases.

PHASE III DUAL USE APPLICATIONS: Dual-use potential for this technology is very high because a number of the DoD systems requiring control are commercially acquired and because it will also be applicable to many other commercial and private combustion systems, all of which are expected to come under pressure to decrease fine-particulate emissions.

REFERENCES:
1. Air Pollution Control Methods, Kirk|Othmer Encyclopedia 3rd Ed., pp. 766|825.
2. Sittig, M. [1977]. Particulates and Fine Dust Removal, Noyes Data Corp., pp. 510|512.
3. Bergman, W., Biermann, A.H., et al. [1983]. "Electrostatic Air Filters Generated by Electric Fields," Particulate Systems: Technology and Fundamentals, p. 57.

KEYWORDS: Soot, PM2.5, Combustion

AF99-168 TITLE: Perchlorate Sensing Technology

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Develop and demonstrate an in situ capability to detect and quantify perchlorate at the part per billion level in groundwater.

DESCRIPTION: For decades the US Air Force has used ammonium perchlorate as an oxidizer in rocket propellants. During the manufacturing process, waste streams containing varying concentrations of ammonium perchlorate have been discharged into the environment and have found their way into aquifers and drinking water sources. Testing methods have evolved to push the minimum detection level for perchlorate from the part per million level to the part per billion level. The Environmental Protection Agency has identified perchlorate as a hazardous contaminant and established an action threshold of 18 ppb. The current need is for a quick, inexpensive, field portable in situ capability to detect and quantify perchlorate in groundwater at the ppb level. Measurements are expected to support site characterization as well as long term monitoring. An ultimate goal is to integrate this capability with the E-SMART network of smart sensors.

PHASE I: Phase I will result in the laboratory demonstration of a technology and methodology to detect and quantify perchlorate in groundwater samples that has the potential for practical in situ application. The Phase I efforts will be documented in a technical report.

PHASE II:Phase II will develop an engineering model employing the capability demonstrated in Phase I, and demonstrating the device in a field situation. Phase II will include analysis of the unit cost, cost per measurement, and cost of ownership for the device. The Phase II effort will be documented in a technical report.

PHASE III DUAL USE APPLICATIONS: With the promulgation of the Safe Drinking Water Act, each provider of drinking water needs a capability to detect perchlorates. The immediate potential is for those drinking water providers near rocket propellant processing facilities.

REFERENCES:
1. ESOH Need 1927, "Additional information on ammonium perchlorate developmental bone marrow, and thyroid toxicology are needed to refine the human risk assessment."
http://xre22.brooks.af.mil/hscxre/97tns/97needs/1927.htm
2. High levels of perchlorate are detected in a monitoring well at the Kerr-McGee plant near Henderson.
3 . http://www.lvrj.com/lvrj_home/1997/Sep-05-Fri-1997/news/6005670.html

KEYWORDS: Sensing, Ammonium, Monitoring, Perchlorate, Groundwater, Rocket Propellant

AF99-169 TITLE: Advanced Coatings Systems

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Research and development leading to advanced aircraft coating systems capable of providing extended service lifetimes as defined below.

DESCRIPTION: Aircraft painting/stripping/repainting processes and handling the associated hazardous waste is one of the highest cost maintenance activities in the Air Force. The Air Force Coating System Strategy applies to almost all operational aircraft and identifies aircraft coating system requirements from now until beyond the year 2003. In addition to environmental compliance, the

strategy clearly defines long term coating system performance parameters of 30+ years durability in corrosion protection and 8+ years durability for topcoats, which are significantly beyond the current state-of-the-art. These longer life and environmental requirements apply to both conventional aircraft coatings and specialty materials, such as optical coatings, used by the Air Force.

An advisory panel of internationally recognized experts in the fields of coating technology and corrosion science and engineering from industry and academia, was chartered to study the potential of a basic research contribution to ameliorate the aircraft paint issue. The panel recommendations lead to a programmatic course of action enabling for the Air Force to meet its stated objectives by the year 2003. The following three areas of research and development activity are currently underfunded and are herein identified for investment:

1. High durability, corrosion resistant surface treatments and permanent primer coatings capable of providing corrosion protection for a 30+ year life cycle using environmentally benign materials.
2. Identification of mechanisms of aircraft coating failures around rivets and panel edges, and other localized high strain areas of the aircraft leading to accelerated corrosion and topcoat damage. Results should lead to development of improved approaches to coatings and accelerated tests for evaluating surface treatments, primers and flat (matte) topcoats.
3. Demonstration of novel formulation/component concepts and materials (polymers, additives, pigments, corrosion inhibitors, etc.) for low/no VOC flat (matte) coating systems that will lead to formulation of coating systems providing improved cleanability, mar resistance, chemical resistance, rain erosion resistance, and lifetime.

Research and development programs are sought which address the unique operational requirement of a permanent 30-year corrosion surface treatment/primer protection life cycle and 8-year topcoat requirement.

PHASE I: The establishment of viable approaches to addressing key elements of the above three research and development areas are sought in Phase I.

PHASE II:Follow-on efforts in Phase II will further develop and optimize the elucidation of mechanisms, development of models, and/or synthesis of advanced materials using the approaches established in Phase I.

PHASE III DUAL USE APPLICATIONS: The commercial aircraft industry will benefit because much of the technology developed will be directly applicable. The auto industry also has a great need for corrosion protection as well as a need for predicting and extending the life of coatings for cars and trucks.

REFERENCES: SBIR Requirements Documents based upon the "Report of the AF Blue Advisory Panel on Aircraft Coatings, Part 1 - Basic Research", the Air Force Coating System Strategy draft "Operational Requirements Document" (ORD), and the "Advanced Performance Coating Document" will be available on the AFRL/ML web site.

KEYWORDS: Resin, Topcoat, Aircraft, Application, Formulation, Rain Erosion, Coating System

AF99-171 TITLE: Novel, Regenerable Filter for Dusts and Sticky Mists

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Develop and demonstrate a cost-effective technology that will remove fine dust and mist particles from a ventilation air stream with minimum waste generation or conversion of the captured particles into environmentally benign products.

DESCRIPTION: Revisions to NAAQS being imposed under Title I of the Clean Air Act will require the application of effective measures to decrease emissions of particulate matter finer than current technology is expected to manage. Modifications to (other than cessation of) the generating processes are not expected to contribute significantly to this reduction, so options for effective, affordable control are needed. Desirable qualities for the technology include capability of extended periods of unattended operation in a start-and-stop application, compactness, and minimal pressure loss. Use of exotic or hazardous materials, or requirement for unusual expertise to operate or maintain the technology will be considered negative factors in selection.

PHASE I: Develop and conduct a bench-scale demonstration of the technical principle(s) upon which the control strategy is dependent. Perform a preliminary analysis of the estimated cost to apply the technology to one or more candidate sources. Develop a commercialization plan, identifying any partners and other resources.

PHASE II:After additional development, assemble and test a pilot-scale engineering model of the technology in a controlled environment. After any necessary modifications and adjustments, test the performance of the pilot system on an actual source (or a split of the exhaust from an actual source) at an operational site to be agreed upon with the POC. The test will include measurement of performance, treatment by-products, consumption of any added materials, energy usage, operator time, and any other factors contributing to costs. Data from the test will be used to perform a more-refined analysis of the cost of applying the technology to several general cases.

PHASE III DUAL USE APPLICATIONS: Dual-use potential for this technology is very high because a number of the DoD systems requiring control are commercially acquired and because it will also be applicable to many other commercial and private

environments (e.g., indoor air in buildings, transportation, and isolated enclosures; exhaust air from industrial and craft fabrication, finishing, and refinishing facilities), all of which are expected to come under pressure to decrease fine-particulate emissions.

REFERENCES:
1. Air Pollution Control Methods, Kirk|Othmer Encyclopedia 3rd Ed., pp. 766|825.
2. Sittig, M. [1977]. Particulates and Fine Dust Removal, Noyes Data Corp., pp. 510|512.
3. Bergman, W., Biermann, A.H., et al. [1983]. "Electrostatic Air Filters Generated by Electric Fields," Particulate Systems: Technology and Fundamentals, p. 57.

KEYWORDS: IAQ, PM2.5, Mists, Abrasive, Painting, Fine dusts

AF99-174 TITLE: Development of Highly Anti-Reflective Surfaces for Semiconductor Wafers

TECHNOLOGY AREA: Materials, Processes and Structures

OBJECTIVE: Design and fabrication of high performance antireflection surfaces for infrared optical materials

DESCRIPTION: Semiconductor compounds and alloys such as mercury cadmium telluride (MCT) have important applications in the infrared, for example, as infrared detectors or as optical elements. High quality anti-reflection (AR) coating is desired for many of these applications. Traditional method AR coating, the evaporation of thin films on to semiconductor surfaces, is made difficult by the fact that the optimal substrate temperature is often higher than the temperature at which significant degradation of the material starts to occur. Also, the thin film coatings are often unable to withstand a large number of cycles between room and cryogenic temperatures. An alternative way to obtain high performance, antireflection effect over desired wavelength ranges is to use surface structure modification (1,2). This technique provides an additional advantage in that it obviates the need to use complicated coating designs often involving radioactive materials. Moreover, these surfaces would exhibit intrinsically hard laser damage performance in high-power laser applications. Proposals are solicited to develop the technique and to provide high quality AR surfaces with average reflectivity < 5 % in the 3 - 5 micron and in the 8 - 12 micron spectral ranges, on semiconductor materials that cannot be heated beyond 45 - 50 degrees C.

PHASE I: During this phase the offeror will evaluate the design trade-offs based on various fabrication (especially etching) techniques available and perform preliminary proof-of-concept validation experiments.

PHASE II: Optimize the processes to achieve performance or capabilities not currently available. Design, fabricate and characterize a test article based on the developed process which demonstrates an advance in the state-of-the-art surface modification method.

PHASE III DUAL USE APPLICATIONS: Infrared detection systems are predicted to be used in numerous civilian and medical markets, including surveillance, pollution monitoring, thermography etc. The durability and manufacturing simplicity of antireflction surfaces brought about by this program would result in improved cost-effectiveness and efficiency of existing and future infrared detectors.

REFERENCES:
1. Wilson and Hutley, The optical properties of the moth eye antireflection surfaces, Optica Acta, Vol 29, No. 7, 1003, (1983).
2. Yeh and Sari, Optical properties of stratified media with exponentially graded index of refraction, Appl. Optics, Vol. 22, No. 24 (1983).

AF99-175 TITLE: Ultra High Performance Soft Magnetic Materials for High Temperature Turbine Applications

TECHNOLOGY AREA: Materials, Processes and Structures

OBJECTIVE: Develop high performance soft magnet materials for use in aircraft integral power units and starter/generators.

DESCRIPTION: The performance and reliability of future aircraft can be greatly enhanced by the use of integral starter/generators (ISGs) and power units (IPUs). These devices can rotate at speeds up to 60000 rpm, creating hoop stresses of approximately 80ksi. Also, the temperature can rise to 550oC. A soft magnet material is needed to withstand these stresses and temperatures while experiencing less than 1% creep over 5000 hours and minimizing electrical losses. The best available FeCo materials available have good strength and magnetic performance but unacceptable creep performance at the operating temperature of these devices. Although silicon steels have good mechanical performance, they do not have the desired magnetic performance at elevated temperatures. The FeCo materials have the best available magnetic properties. Proposals should address manufacturing or compositional methods for

improving the performance of these materials at elevated temperatures. Proposals may also address other materials capable of providing magnetic performance comparable to FeCo while achieving the mechanical and electrical loss goals.

PHASE I: Develop and demonstrate a material (alloy, composite, matrix, ceramic, etc.) capable of sustained high mechanical and magnetic and electrical performance even at elevated temperatures. This includes developing ceramic coatings to minimize core loss and exploring bonding laminates to form monolithic rotors.

PHASE II: Further optimize the performance of these materials and coatings as well as their manufacture. Additionally, a monolithic type rotor with high strength, low creep and high magnetic performance may be developed.

PHASE III DUAL USE APPLICATIONS: Improved high temperature capable magnetic materials have a significant potential for dual use in commercial applications of IPUs. The benefit of the More Electric Aircraft concept to commercial aircraft will be very significant and parallel those for Air Force applications. Additional applications can be found in alternative fuel vehicles and magnetic bearings for use in industry and power generation facilities.

REFERENCES:
(1) "More Electric Aircraft Integrated Power Unit Designed for Dual-Use", R. M. (Fred) Klaass and Dr. Buryl McFadden, SAE Paper No. 941159, Society of Aerospace Engineers, 1994.
(2) "The Integral Starter/Generator Development Progress", E. Richter, R. E. Anderson, and C. Severt, SAE Paper No. 920967, Society of Aerospace Engineers,1992.

KEYWORDS: permanent magnet materials, soft magnetic materials, rare earth magnets, iron-cobalt alloys, magnetic bearings, auxiliary electrical power

AF99-177 TITLE: Semiconductor Alloys for Mid-Infrared Applications

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Develop binary, ternary or quarternary semiconductor alloys in bulk form having band-gap in the 0.2 to 0.45 eV range.

DESCRIPTION: Ternary or quarternary alloys of In | Ga | Al | Sb or As can provide materials having band gap energies that can be selected by choice of the alloy composition. Such materials have been grown with the bandgap energy in the 1 | 1.5 eV range in both bulk and thin film form. For mid-wave infrared applications, it is desirable to obtain bulk material having bandgap in the 0.2 to 0.45 eV range. Binary alloys such as Te | Se with appropriate alloy composition would also provide material with appropriate band-gap. Proposals are solicited to develop such materials having good optical and surface properties along with low free carrier, impurity or defect concentration that can be fabricated into disks that are approximately 2.5 cm in diameter and 2 | 3 mm in thickness.

PHASE I: During this phase the offeror will demonstrate the feasibility of the materials and the practicality of the process to develop them, to give a proof of principle and identify those materials/process issues which must be addressed during Phase II of the program.

PHASE II:Optimize the materials and/or processes to achieve performance or capabilities not currently available. Design, fabricate and characterize a test article based on the developed materials or process which demonstrates an advance in the state-of-the-art.

PHASE III DUAL USE APPLICATIONS: Alloy materials developed in bulk single crystalline form has the potential to provide materials with continuously variable lattice parameters between binary compounds and can serve as substrates for layers of various III-V or II-VI materials used extensively for manufacture of laser diodes and detectors for a broad range of commercial applications.

KEYWORDS: alloy, Ternary, quaternary, semiconductor, In-Ga-A1-Sb or As

AF99-178 TITLE: Switchable Microlenses for MEMS Applications

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Develop liquid crystal microlenses for switchable optics applications based on liquid crystal display technologies.

DESCRIPTION: Liquid crystals are used in flat and curved displays and are switchable as in, "Smart Windows", applications. These applications include space, aircraft communications and sensor systems. Microlenses are presently being used in many of these applications along with commercial large area display units. Many new uses of microlenses can be envisioned if the microlenses are switchable, i.e., the lenses appear upon command, otherwise the array containing them is transparent. This will provide an avenue

to increase the light intensity on predetermined subunits composing a neighboring film array. , e.g., non-linear optical material devices. Non-linear and linear optical devices (e.g., rejection filters, graded optical limiters, rugate filters, and dielectric stacks) may be examined as part of a processing and materials effort to evaluate and demonstrate enhanced material performance.

PHASE I: During this phase the offeror will demonstrate the fabrication feasibility of liquid crystal microlenses, both standard and refractive. Refractive microlense fabrication could entail a major study in phase decomposition kinetics of applicable polymer dispersed liquid crystal systems.

PHASE II:During this phase of the program the offeror will optimize the switchable liquid crystal microlense array processing technique. The offeror will design, fabricate, and characterize a test article based on the developed technology in Phase I. The test article should demonstrate enhanced optical properties (e.g., optical limiting, linear or non-linear absorption, linear or non-linear refraction, etc.) over those devices presently used in the application area.

PHASE III DUAL USE APPLICATIONS: Microlenses technology is principally used in the commercial display sector, but if switchable (on/off, but always transparent), many military applications will benefit.

KEYWORDS: PDLC, Displays, Microlenses, Liquid crystals, Optical limiters, Non-linear absorption, Non-linear optical materials

AF99-179 TITLE: Munition Modeling and Technology Integration Research

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Assess weapon lethality, effectiveness, and utility; evaluate expected weapon performance; develop concepts for munition integration.

DESCRIPTION: New and innovative concepts in the area of air delivered conventional munitions are sought. The Assessment and Demonstrations Division of the Air Force Research Laboratory Munitions Directorate conducts research and directs exploratory development of advanced munition integration concepts. Munition integration areas under consideration include highly agile air-to-air missiles, air-to-surface munitions (unitary, penetrator, and dispensers), submunitions, and projectiles. Technology areas under consideration include aerodynamic shaping, advanced structural/material design application, innovative control surface stowage and deployment for compressed carriage, dispense and interface technologies (especially multiple carriage and dispense of small munitions), innovative flight controls and maneuver techniques (i.e., reaction controls, micro-adaptive control, etc.), and terradynamic control. Munitions integration with unmanned combat air vehicles is a key technology area. Interest areas also include hypersonic airframes, time-critical target defeat, bomb damage identification and bomb damage assessment, and non-lethal target defeat. Modeling and simulation tools of interest include high-fidelity physics based codes for warhead design and penetration analysis, engineering level tools for weapon/target interaction analysis, and improvements for theater level modeling of many-on-many combat. Also sought are models which enable prediction of the functional relationship of fire and/or blast effects on fixed structures as related to type of source explosive and models to optimize capability for evaluating dispersion of chemical/biological neutralization agents in a high-temperature, high-pressure environment.

PHASE I: Determine the technological or scientific merit and feasibility of the innovative concept. The merit and feasibility should be clearly demonstrated during this phase. A technical evaluation of the concept or methodology, a demonstration of proof of principal, or a description of a technical approach, alternative approaches, and associated risk factors may be appropriate.

PHASE II:Produce a well-defined deliverable prototype or munition-related simulation capability.

PHASE III DUAL USE APPLICATIONS: The military end products or processes resulting from this topic will be used to develop advanced munition airframes. Each proposal submitted under this general topic should have an associated dual-use commercial application of the planned technology. The commercial application should be formulated during Phase I. Phase II will require a complete commercialization plan. Innovative flight vehicle technologies could improve air vehicle performance, as would air foil products, i.e., wind turbines, turbomachinery, etc. Simulations of effects would reduce test costs and provide greater capability for safety officials and insurance underwriters to assess associated hazards. Improved simulation models using advanced analytical methodologies would be of value to a wide variety of commercial activities requiring analysis of the effectiveness of operations or product quality or performance. These developments could benefit commercial building demolition, safety-related assessments, auto safety research, explosives research, mining, drilling, and a wide range of product analysis and evaluation activities.

KEYWORDS: weapon, airframe, munition, assessment, simulation, demonstration

AF99-180 TITLE: Ordanance Research

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Identify, develop, and demonstrate commercial components having application to air deliverable munitions.

DESCRIPTION: New and innovative ideas/concepts are needed in the area of air delivered, non-nuclear munitions that have a dual use/commercialization potential. Military products include bombs; penetrators; submunitions; warheads; projectiles; fuzes (including safe and arm devices); explosives/energetic materials; time delayed, self-degrading explosives; genetic engineering of molecular explosives; polymer binders for shock survivable explosives; fiber optics; solid state inertial components; exterior ballistics; test technology; modeling and simulation resources and techniques; and conventional weapon environmental demilitarization and disposal techniques. Examples of desired research are target detection sensors for deeply buried targets; warhead initiation; self-forging fragment warheads; shaped charges; reactive fragment warheads; hard-target weapon/penetration technology; near field backscatter modeling for 60 to 300 GHZ detection devices; energetic materials; and low velocity deep earth penetrators. Concepts and methodologies for defeating and neutralizing chemical and biological agents during production, storage, and employment in weapons of mass destruction are desired. Technologies for denying enemy access to weapons of mass destruction are also of interest. Rapid solid-state reaction, combustion and detonation process models for metallic particle systems are of interest. These models should include energy extraction rate, theoretical descriptions of initiation, and kinetics of reaction. Process models shared also account for the physical processes unique to metallic particle energetic systems. Metallic particle sizes of interest are 10-100 nanometers. Models developed should provide insight into the impact of parameterization of particle size, surface area, and heat conduction rate as related to initiation and reaction behavior.

PHASE I: Determine the technological or scientific merit and feasibility of the concept.

PHASE II:Provide a deliverable product or process.

PHASE III DUAL USE APPLICATIONS: A wide range of commercial products could be produced from this research. Typical products include propellants, initiators, gas generators, high strength and high strain rate materials, low cost sensors/detectors, and environmentally compatible recycling processes for energetic materials. Each proposal submitted under this general topic should have an associated dual-use commercial application. Phase II will require a complete commercialization plan.

REFERENCES:

1. Progress in Astronautics and Aeronautics: An American Institution, by Martin Summerfield, Volume 21, Academic Press, 1963.
2. Dynamic Aspects of Detonation: Progress in Astronautics and Aeronautics, Volume 153, Book Publication of AIAA.

KEYWORDS: fuzes, warheads, explosives, simulation, nanoparticles, target detection, hard target defeat, safe arm fire devices, chemical neutralization

AF99-181 TITLE: Guidance Research

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Develop innovative concepts in guidance technologies for air deliverable autonomous munitions

DESCRIPTION: The Advanced Guidance Division of the Air Force Research Laboratory Munitions Directorate seeks new and innovative ideas/concepts in areas related to closed loop guidance, navigation and control of autonomous munitions. Topics of primary interest in navigation include very small, low cost inertial measurement units (IMUs), Global Positioning System (GPS) guidance, jam resistant GPS, and transfer alignment. Topics of interest in guidance technology include optimal guidance law development, target state estimators, and advanced adaptive autopilots. Topics of interest related to seekers include electrooptical, millimeter-wave, and radio-frequency seeker technology and the components and signal processing systems used in such seekers for autonomous guided munitions. This includes, but is not limited to, sources, detectors, polarization-sensing elements and systems, modulators (both single element and pixelated), pattern recognition and processing systems, and basic material and device development for accomplishing all of these; polarization-sensing elements and systems for studies of the utility of such systems for target characterization and discrimination; developing algorithms for use within autonomous target acquisition (ATA) applications; innovative signal and image processing algorithms used, for example, in synthetic aperture radar (SAR), millimeter-wave (MMW), imaging infrared (IIR), and laser radar (LADAR) needed to autonomously detect and recognize target signatures embedded in backgrounds; operations/functions associated with the ATA process involving noise elimination, detection, segmentation, feature extraction, classification (e.g., truck vs. tank), and identification (e.g., tank A vs. tank B); utilization of Image Algebra in the development of non-proprietary ATA algorithms. Algorithms capable of processing/fusing multi-sensor data are of particular interest. Key research areas include signal and image processing, pattern recognition/classification, image understanding, artificial

neural networks, fuzzy logic, superresolution, knowledge- and model-based vision, and data fusion. Topics of interest related to modeling and evaluation include synthetic target signature generation and scene projection technology for hardware-in-the-loop applications. Concepts must have a good dual use/commercialization potential.

PHASE I: During Phase I, the offeror shall determine the technological or scientific merit and the feasibility of the innovative concept.

PHASE II:The Phase II effort is expected to produce a well defined deliverable product or process.

PHASE III DUAL USE APPLICATIONS: Each proposal submitted under this general topic should have an associated dual-use commercial application of the planned technology. The commercial application should be formulated during Phase I. Phase II will require a complete commercialization plan.

KEYWORDS: LADAR, seekers, jam resistant GPS, artificial neural networks, guidance of autonomous munitions, algorithms for Autonomous Target Acquisition (ATA)

AF99-182 TITLE: Control of Large Micro-Eletro-Mechanical Systems (MEMS) Array

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Develop methods of controlling Hyper-Input/Hyper-Output (HIHO) systems of large arrays of MEMS.

DESCRIPTION: Investigate and demonstrate the feasibility of integrating hundreds/thousands of micro-fluidic actuators and sensors for flight control of a generic munition. The use of MEMS fluidic arrays in munitions applications has the potential to measure and control performance limiting physical phenomena such as flow separation, vortex dynamics, and turbulence. Better control of these phenomena through the use of Hyper-Input/Hyper-Out (HIHO) micro technology can lead to enhanced munition agility and performance. The mathematics required for the stabilization and control of large array structures has been previously developed, but these techniques cannot yet be directly applied for the munitions problem. The issue is to develop surface allocation strategies that produce forces and moments (which are by some measure optimal) which result in a controllable airframe. The dual problem of observability must also be addressed in the context of HIHO micro technology.

PHASE I: Proof-of-concept for this project should develop a design methodology and demonstrate the feasibility of implementing a HIHO control algorithm for a generic munition using MEMS fluidic actuators and sensors for control. The Phase I portion of this program should deliver a guided munition simulation incorporating the entire sensor/control scheme and design models used. A proposed air-frame should be recommended for implementation during the Phase II portion of the program.

PHASE II:Phase II would involve applying the design and testing performance on a hardware in the loop vehicle for the HIHO control algorithm and sensor fusion approaches.

PHASE III DUAL USE APPLICATIONS: Commercialization potential includes products which require control and coordination of arrays of micro sensors and actuators such as: sensors for automotive industry (pressure and acceleration), thermal inkjet print-heads, deformable mirrors, optical displays, and microfluidic devices for the medical industry.

KEYWORDS: MEMS, sensor fusion, fluidic arrays, micro-actuators, distributed control, micro pressure sensors, control surface allocation

AF99-183 TITLE: High Power Microelectronics Technology

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Develop high power microelectronic devices having both military and commercial application.

DESCRIPTION: Recent advances in the microelectronics industry have resulted in technologies which allow the use of smaller devices to perform certain electronic functions. In particular, advances have been made in both energy storage and power switching which allows for more performance per unit volume. Advances in the high energy density capacitor industry have resulted in increased energy storage in smaller packaged units. The goal of any effort in energy storage is to fabricate a low-cost capacitor with a minimum capacitance of 10-20 millifaraed, a voltage stability of 10 - 28 volts DC and an equivalent series resistance of 200 milliohms or less at room temperature. Power switching has evolved to a point where fast switching and high breakdown voltages are simultaneously achieved in micro sized devices. The focus of any effort in power switching is to develop microelectronic high power devices that have very short function delay (less than 50 nanoseconds) and are capable of reliable operation with a hold off voltage of 2 kilovolt and a large off-state resistance of more than 100 megohm. The focus of these efforts is to develop and fabricate

commercially viable technologies that have military applications.

PHASE I: Phase I of this project should focus on the materials employed for these applications and the fabrication of these devices. For high energy density storage devices, an investigation could focus on the use of commercially available electrodes and electrolytes and alternative materials for the electrode. For high power switching applications, an investigation of the feasibility of modifying existing power semiconductor devices to meet the specific needs of military electronic fuzing could be conducted. The design of a prototype device(s) should be available by the end of Phase I.

PHASE II: Phase II should focus on the fabrication of devices with an emphasis on alternative materials and increased power density devices. A certain number of device(s) should be delivered for evaluation as a part of Phase II.

PHASE III DUAL USE APPLICATIONS: This area of research is unlimited in its use in both commercial and military markets. Any advances in this technology could be utilized by the cellular communications industry for longer battery life and a higher amplitude signal. In addition, applications in high power inverters for high voltage conversion of direct current to alternating current that can be transformed for general use and power microwave communication systems can also be realized. This technology would also be viable for commercial markets currently using similar technology.

REFERENCES:

1. W.F. Mullin, ABC's of Capacitors, Howard W. Sams, Inc., Indianapolis, IN, 1978

2. J. Vitins, J. L. Steiner, and J. A. Welleman, "High Power Semiconductors for Pulsed Switching," Seventh IEEE Pulse Power Conference (1989) pp 352-357.

KEYWORDS: electrolytes, firing systems, energy storage, aluminum hybrid, high power semiconductors, high speed solid state relay, capacitors (high surface area), microelectronic high power devices

AF99-184 TITLE: Electrical Disablement of Large Structures and Vehicles

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Develop electrical energy transport and/or conversion mechanisms for conventional warheads target neutralization.

DESCRIPTION: Advances in Explosive Flux Compression Generators (EFCG) and pulsed electrical power generation have opened the door to new opportunities in nonlethal incapacitation for law enforcement agencies and less than lethal conventional munitions for disablement of structures and vehicles. Compact, high-energy electrical sources can be integrated into weapon systems as part of an alternate lethal mechanism or as energy storage devices for a non-traditional explosive techniques. The use of an electrical warhead system could result in smaller munitions delivering equivalent energy to targets while, at the same time, increasing their effectiveness in neutralizing important assets. Implementation of an electrical warhead may be done in a variety of ways such as directly coupling an electrical pulse to a target using methods such as pulse coupling, explosively deployed conductors, high energy lasers, shaped-charge jets (2), conductive fluids, or conductive gases. Alternatively, certain classes of energetic materials might benefit from pulsed electrical power in terms of enhancing target interactions or reducing collateral damage. Presently, the Air Force Research Laboratory Munitions Directorate is investigating air-launched munitions to defeat a wide variety of electronically significant targets in both lethal and non-lethal modes. The goal of this topic is to encourage ideas that use non-radiative electrical energy to improve target neutralization capabilities and to increase the effectiveness of conventional explosive munitions.

PHASE I:Efforts should be concerned with formulation of system concepts based on lethal and nonlethal effects. The formulation of concepts should be followed by verification of the order of magnitude of the proposed effect. This verification should be accomplished through analysis or experimentation. Effects of interest are those which inflict wide spread damage, disruption and denial of electronic equipment, computers, communication systems, and power utility systems.

PHASE II:Concentrate on well designed experiment to demonstrate various components of the proposed target defeat system conceived during Phase I. Fabrication of proposed system components and execution of the scaled or full-scale experiments will be conducted during Phase II to verify that the alternate lethal mechanism is feasible and worthy of Phase III consideration.

PHASE III DUAL USE APPLICATIONS: Component technology developed in this field will benefit the commercial well drilling and mining community in the development of compact high energy power sources, pipe perforation systems, compact multi-point initiators, firesets immune to high magnetic fields, advanced high energy explosives, bore-hole to bore-hole tomography and compact shaped-charge jets. In addition, law enforcement would benefit greatly by technologies to immobilize vehicles or deny access to facilities without lethal effects to inhabitants. Electrically triggered non-explosive materials can significantly increase the safety and reduce costs for all industries that presently use conventional explosives. Additional commercialization potential is realized with active lightning protection for high value commercial and government assets, wireless transmission of electrical power, artificial triggering of lightning and police/security force non-lethal vehicle stopping devices. The Air Force Research Laboratory Munitions Directorate may also separately fund a follow-on Phase III effort for actual integration and testing of new lethal mechanisms in

appropriate weapon systems.

REFERENCES: "FY98 Technology Area Plan (TAP)", Air Force Research Laboratory Munitions Directorate, Eglin AFB, FL, 32542-6810, (850) 882-0266/9643.

KEYWORDS: warheads, pulsed power, electromagnetic, enhanced lethality, conventional weapons, nonlethal disablement, explosive pulsed power, reduced collateral damage, electrical explosive enhancement

AF99-185 TITLE: Micro-Electro-Mechanical Systems (MEMS) Technology for System Safety and Control

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Demonstrate low voltage, low energy components compatible with Micro Electromechanical Systems (MEMS) for safing systems.

DESCRIPTION: Recent advances in MEMS technology have resulted in the demonstration of environmentally and electrically activated devices applicable to safe, arm, and fire (SAF) systems that include electromechanical decoders, rotors and sliders. These devices could potentially become significant in reducing the size and cost of safety systems in conventional weapons. There are, however, significant "missing links" in the technology that would prevent it from reaching its full potential. One link is the technology required to achieve low energy (less than 0.1 milijoule), low voltage (5-volt), initiation mechanisms (detonators) that are capable of being interrupted by movements (of 20 mils) with a MEMS SAF device. Current non-MEMS devices require 250-mil movement to inhibit initiation. The goal of this effort is miniaturization of low energy, electrically activated devices that would allow for the use of MEMS SAF devices. It is anticipated that new and unique approaches to the electrical release of chemical energy and the efficient coupling of the chemical energy to some type of mechanical energy (i.e. flyer) and prime movers will be required.

PHASE I:Investigate the feasibility of the proposed concept. This investigation should include energy transfer mechanisms, detonation of a high-density secondary explosive at a point past the anticipated barrier, and the capability of preventing the secondary explosive functioning by MEMS scale devices

PHASE II:Focus on the design and fabrication of components of the SAF system. The final demonstrations should include actual firing of output charges and determination of the effectiveness of the barrier intercouple or other detonation prevention mechanism. A quantity of items will also be delivered to the government for evaluation at the end of Phase II.

PHASE III DUAL USE APPLICATIONS: The evaluation of a systems safing device in MEMS scale which is compatible with high volume production can benefit the electro-explosive and computer control systems industry. The employment of MEMS with electro-explosive devices could lead to new and unique applications in many emergency areas such as the "Jaws of Life."

REFERENCES: See website: http://www.mdl.sandia.gov/micromachine/

KEYWORDS: detonators, initiators, micromachines, micro electromechanical systems

AF99-186 TITLE: Wireless Data Transmission Through Various Media

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Develop and demonstrate a miniature, high shock resistant data link for transmitting information in an underground environment.

DESCRIPTION: The ability to transmit data from an underground location to a relay device on the surface is desired. Applications such as shallow mining, urban below street data transmission, and real-time transmission of data from a penetrating weapon including post penetration transmission, are sought. The Air Force is interested in transmitting smart fuze data from penetrating weapons to provide battle damage information. This information must be transmitted from the buried weapon through layers of soil, concrete and other media such that it arrives at a receiver located at ground level or is available to aircraft in the area. This program will examine methods for collecting and relaying information from a penetrating weapon to a receiver. Systems to transmit data should be proposed by the respondent. As an option, the respondent may propose new systems for collecting and relaying the data required to assess target damage. Technology such as microelectromechanical systems (MEMS) maybe considered for the collection and transmission of real time bomb damage information in the post-event environment if their survivability can be verified.

PHASE I:Phase I of this project will identify a method of obtaining battle damage information (BDI) from weapon born sensors (WBS). The WBS will be contained or attached to an air delivered penetrating weapon. This project will develop a WBS

concept and analytically determine the feasibility of data transmission through dense target media. The feasibility of packaging the concept in a penetrating weapon will be determined. The critical post-event information to be collected and transmitted will be identified (e.g. ambient pressure and temperature, ambient gas content and sound video).

PHASE II:Phase II will fabricate and demonstrate the WBS system or data transmission system for a WBS. A shock hardened transmitter system will be built and tested on shock machines and in gun launches against hard targets. Demonstrations will be conducted to insure that data can be transmitted through various media. Real time battle damage assessment (or bomb damage information) sensors must be designed and fabricated based on the requirements defined in Phase I. These devices must be capable of withstanding the munition penetration/explosion events.

PHASE III DUAL USE APPLICATIONS: This project will provide useful wireless transmission research to both military and industry. Advances will enable development of wireless underground communications for shallow mining, urban below street access tunnels and emergency communications for subways. Ruggedized micro sensing devices may also have applications in industry machinery to monitor and regulate manufacturing processes.

REFERENCES:

1. H. Heys, "Digital Communications - Encoding", 3rd edition (1994)
2. Internet article, "Data Encoding Modulation", http://192.107.38.102/cpe471 (1997)
3. Internet article, "Data Encoding", http://www.csm.ohiou.edu (1997)

KEYWORDS: penetration fuzing, hard target weapons, weapon borne sensor, battle damage information, shock-hardened transmitter, dense media data transmission

AF99-187 TITLE: Integrated Guidance - Exploitation of Body-Shading for Anti-Jam GPS

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Demonstrate an integrated guidance algorithm to exploit body-shading and antenna gain patterns for anti-jam GPS.

DESCRIPTION: Provide a technical basis from which an integrated guidance navigation design approach can be leveraged for precision munitions. The design approach has application to many functional areas: guidance fuzing integration for mass focused ordnance technology, guidance control integration for reduced radar cross section of cruise missiles, and anti-jam GPS capability based on body shading. The specific application of integrated guidance for this program is to investigate the feasibility and demonstrate an anti-jam GPS capability based on exploitation of body shading. It is currently common to select a GPS receiver antenna and place it on a guided munition air-frame in such a way as to minimize acquisition time and the effects of ground based jammers. Basically the antenna system is placed in such a way as to maximize the GPS signal received during a typical mission scenario. It is possible to exploit this same concept during the guidance maneuvers of the vehicle as well. Since the GPS satellites and jammers are typically not co-located, the air-frame can be steered so that the antenna gain pattern is pointed where satellites are located. This concept can also be used to maximize GPS accuracy by optimizing antenna direction relative to the satellite constellation. Current guidance algorithms do not directly attempt to actively exploit the above concepts. In the past, guidance algorithms for munitions have focused on minimizing miss distance or maximizing kinetic energy at impact; the increasing reliance on GPS for navigation suggests these new criteria for optimal guidance involving the minimization of the jamming energy received at the antenna. This method of anti-jam GPS is significantly different than the signal processing techniques which are commonly employed.

PHASE I: The first portion of this project will be an investigation that quantifies the benefit of using the effects of body-shading to provide some level of anti-jam GPS capability. The concept is to develop a full envelope guidance algorithm that satisfies both initial and final conditions for a ground fixed target and exploits body-shading. The Phase I portion of this program should deliver a guided munition simulation incorporating the guidance algorithm. The Phase I effort should investigate the sensing requirements (what sort of knowledge ((accuracy)) is required on the location of the jammers) for this sort of anti-jam technique.

PHASE II: The second phase of this project should apply the guidance algorithm developed under Phase I to a representative piece of hardware. Selection of GPS antenna/receiver and experimental identification of the antenna gain as a function of vehicle orientation will be required. A proposed air-frame would be the diamond-back Miniature Munition Technology Demonstration (MMTD), although the Phase I effort may identify a better candidate. These experimental results would then be used for detailed simulation of the concept munition. Depending on cost, it would be desirable to incorporate signal processing techniques providing anti-jam capability for an integrated anti-jam solution.

PHASE III DUAL USE APPLICATIONS: The exploitation of anti-jam guidance algorithms based on exploitation of body shading would have direct application to the next MMTD system (scheduled to demonstrate an anti-jam capability.) In addition to the military application, the formulation of guidance algorithms that minimize non-standard cost functions has application in the area

of robotics. Robots that search inhospitable regions (radioactive environments for example) would be able to use the concepts developed here directly. Such environments often have hazards that mathematically can be represented much the same way as GPS jammers.

REFERENCES: NAIC-ID(RS)T-0067-96, "The United States Military Begins to Recognize the Susceptibility of the Global Positioning System to Jamming," Feb 1996. ADA 304637

KEYWORDS: GPS, control, guidance, anti-Jam, navigation, antenna Gain, body-Shading

AF99-188 TITLE: Biomimetic Applications for Autonomous Guided Munitions

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Leverage understanding of insect neurobiology to develop novel autonomous munition closed loop guidance systems.

DESCRIPTION: Life forms as well as smart munitions collect visual, inertial, and kinesthetic information from the environment, process it, and make decisions. Decisions may be object detection, identification, a change of position for better tracking or acquisition, or a navigation or guidance decision. Much research aimed at understanding natural paradigms has been previously accomplished to address biomedical objectives. There have been previous successes from exploiting natural paradigms, such as neural networks, genetic algorithms, and evolutionary computation technologies. Specific sensory applications include vision chips performing outer retinal processing in the analog domain. Other hardware demonstrations have modeled auditory, olfactory, and cortical processing functions. Models of insect guidance and navigation sensors and control functions and mechanics of movement could be used for closed loop guidance, navigation and control functions. It is desired to leverage the knowledge of structure and functionality of these and other natural systems to guide the development of innovative autonomous guided munition system concepts. Any innovative integration of previously demonstrated biomimetic guidance components will be given favorable consideration. While leveraging biomedical understanding, this SBIR project should also leverage commercially available hardware and software technology to ensure maximum sensor capability at affordable production costs.

PHASE I: The proposal should identify candidate biological paradigms and establish a clear understanding of how they relate to the function of an autonomous munition guidance system. The proposal should identify candidate concepts to be explored and demonstrate familiarity with applicable commercial components. During Phase I a hardware prototype system or its significant components should be developed and demonstrated as a proof of concept. Simulations may be substituted if hardware implementation is either trivial or not feasible. The design of a Phase II system should be presented at the end of Phase I.

PHASE II:Develop autonomous components demonstrated and/or designed in Phase I. Demonstrations should be designed so that implementations and commercial system applications are straightforward.

PHASE III DUAL USE APPLICATIONS: The military end product of this anticipated effort will be a seeker prototype leveraging the understanding of biological information processing structures and functionality. This technology could be used commercially in real-time imaging applications, machine vision applications, robotics, and general signal transmission, processing and storage applications.

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1. N. J. Strausfeld, Atlas of an Insect Brain, Springer-Verlag, 1976
2. D. G. Stavenga, R. C. Hardie (eds.), Facets of Vision, Springer-Verlag, 1989
3. M. Burrows, The Neurobiology of an Insect Brain, Oxford University Press, 1996
4. Chapman, The Insects: Structure and Function, 3rd edition, Harvard University Press

KEYWORDS: biomimetics, iInsect flight control, distributed feedback control

AF99-189 TITLE: Multimode/Multispectral Seeker Autonomous Target Acquisition (ATA) Algorithms

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Design, develop, and demonstrate state-of-the-art ATA algorithm approaches applicable to multimode/multispectral seekers.

DESCRIPTION: The precision guidance of autonomous lock-on-after-launch weapons to high value targets, both fixed and mobile, in high clutter backgrounds under adverse weather conditions and low light conditions, represents one of the outstanding challenges

facing the tactical weapons development community today. The application of multimode/multispectral seekers to the smart weapons offers numerous performance benefits over traditional single-sensor implementations. Every seeker has its own peculiar set of advantages and disadvantages when implemented on smart munitions. Frequently, however, individual advantages complement each other such that disadvantages are overcome. The object, then, is to fuse these advantages in an optimal manner. In order to exploit sensor fusion, scene and target registrations are required among the seeker channels. The combining of data or information requires the registration algorithm to account for measurement uncertainty in characteristics shared by the seeker channels as well as in characteristics unique to each seeker channel. The incompatibility of resolution, translation, and registration characteristics of different sensors must be resolved before applying ATA algorithms. Development, evaluation and delivery of state-of-the-art hybrid decision making multimode/multispectral seeker (laser radar and imaging millimeter wave (MMW) channels) ATA algorithms constitute the main thrust of this effort. The proposed concepts and their development should include the design criteria for both image registration and ATA algorithms. The ATA algorithm development should include target detection, segmentation, classification, and identification functions. Conventional, unconventional, and hybrid approaches should be investigated. The assessment of strengths and weaknesses of each approach should be performed.

PHASE I: Assessment of image registration and the hybrid multimode/multispectral seeker ATA algorithms applicable to laser radar and active or passive imaging seeker channels should be performed. A conceptual design including possible conventional, unconventional and hybrid approaches (such as statistical pattern recognition, model-based, artificial neural networks, fuzzy logic, and/or wavelets) should be developed. The inherently low lateral resolution of MMW seekers should be mitigated through use of superresolution algorithms or other innovative means. The sponsor can, if desired, provide an acceptable superresolution algorithm for preprocessing MMW image data. The detailed design of proposed image registration and the hybrid multimode/multispectral seeker ATA algorithms applicable to laser radar with active or passive imaging MMW sensors shall be developed.

PHASE II: The software development based on the conceptual study and design of Phase I will be constructed and demonstrated against measured and simulated data. The data will be provided by the sponsor. The software will be developed on a UNIX hardware platform compatible with the sponsor hardware. The software development should be conducted using a modular software engineering approach. The software will be developed under the Khoros environment and will be fully compatible with the Modular Algorithm Concepts and Evaluation Tool (MACET) software package. MACET software will be provided by the sponsor.

PHASE III DUAL USE APPLICATIONS: Collision avoidance for air and ground transportation, medical imaging, robotics or machine vision, quality control for production systems, commercial surveillance systems, image-recognition systems, and agriculture survey and assessment are all possible commercial applications.

REFERENCES:

1. Qinfen Zheng and Rama Chellappa, " A Computational Vision Approach to Image registration," IEEE transitions on Image Processing, Vol. 2, No. 3, July 1993, pp. 311-326

2. Edward Waltz and James Llinas, " Multisensor Data Fusion," Artech House 1990

3. Lawrence W. Nelson and Ellis Boudreaux, "Raw Data Fusion Using the Generalized Likelihood Ratio," Proceeding of the 7th National Symposium on Sensor Fusion, Vol. 1, March 1994, pp. 251-277

4. Guner Robinson and Omar Aboutalib, "Trade-off Analysis of Multisensor Fusion Levels," Proceedings of the 2nd National Symposium on Sensor Fusion, Vol. 2, March 1989, pp. 21-34

5. J. M. Gillberg, M. Stenoien, and V. Landwehr, "MMW/IR/LADAR Sensor Fusion for Automatic Target Recognition," Proceedings of the 2nd National Symposium on Sensor Fusion, Vol. 2, March 1989, pp. 175-177

KEYWORDS: data fusion, sensor fusion, superresolution, image processing, dual-mode seeker, image registration, image understanding, multispectral sensors, autonomous target acquisition algorithms, automatic target recognition (ATR) algorithms

AF99-190 TITLE: Concrete Building Materials Microstructural Damage Quantification

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Develop experimental analysis tools for quantification of microcracking and void collapse distributions in damaged concrete.

DESCRIPTION: Damage on a microstructural level in concrete has been a difficult problem to detect. Many studies have been done in the civil engineering community, particularly on road and bridge applications, to identify microstructural damage and determine its influence on structural integrity. Studies in penetration mechanics also show that the penetrability of concrete is directly influenced by microstructural parameters. There have been various breakthroughs in techniques for visualizing microcracking and void distributions in concrete. Correlating microstructural characteristics to their effect on the properties of concrete is a significant

technical challenge. The primary focus of this effort is to develop or exploit experimental and visualization techniques for the quantification of microcracking and void collapse distributions in damaged concrete. Once developed, the use of these techniques to relate microstructural parameters to the effect on common material properties such as compressive strength, bulk modulus, and elastic moduli will be explored. The goal is to develop a low cost, experimentally based process to quantify microstructural damage in concrete. Once defined these techniques could then be automated using computer based analysis to quantify microstructural damage and predict influence on material properties.

PHASE I: Phase I of the investigation should concentrate on developing microstructural damage visualization and quantification techniques for concrete. This should include the ability to identify the quantity, distribution, and change of distribution, volume, and change of volume characteristics of microstructural cracks and voids. As a separate or combined effort, computer automated data reduction techniques of microstructural damage could be addressed using existing computer software or through the proposed development of new software.

PHASE II:This phase would focus on developing methods to correlate the observed microstructural damage parameters with their affect on material properties such as compressive strength, bulk modulus and elastic moduli. A separate or combined effort under this phase could also provide for the integration of microstructural damage analysis techniques developed under Phase I into a viable computer software package for automated data reduction.

PHASE III DUAL USE APPLICATIONS: This technology has a broad base of application for both the military and industry. Advances in the quantification of microstructural damage in concrete will have a profound impact on construction, maintenance, hardening, and defeat of concrete structures. Applications to commercial and government construction, maintenance, hardening, and defeat of concrete structures. Applications to commercial and government construction include structural and life cycle analysis for building, roads, bridges, dams, waste and radiation containment systems, hardened structures, and force protection structures. Advances in this area could easily be adapted to fracture in other brittle materials or exploited to enhanced ballistic penetration of these materials. This technology would be invaluable in analyzing earthquake or explosively damage structures.

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KEYWORDS: voids, grout, damage, impact, mortar, cements, cracking, fracture, Concrete, imagining, penetration, petrography, bulk modulus, microanalysis, microcracking, image analysis, microstructure, brittle fracture, geologic materials, concrete structures, compressive strength, modulus of elasticity, scanning electron microscopy

AF99-191 TITLE: Non-Linear Optical Techniques for Imaging LADAR Transceivers

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Develop a LADAR transceiver that implements non-linear optical techniques in novel ways to improve performance.

DESCRIPTION: Past research into imaging Laser Radar (LADAR) transceivers has resulted in systems that use non-linear optical techniques to enhance laser output (output energy or wave length conversion). However, non-linear optical techniques have not generally been used in the receive path where the return pulse is simply focused onto an appropriate detector, and gain in the detector amplifies the signal produced. We propose to investigate the use of non-linear optical techniques in novel ways to explore their effects on system performance. For example, by using an optical amplifier in the return path, the intensity of the return pulse can be modulated before it is focused onto a detector. A particular advantage of such a design would be the ability to optically modulate the effective gain of the receiver, allowing for the exploration of various LADAR detection techniques (e.g. range-gating, coherent detection of intensity modulated pulses, etc.) A range-gating implementation would be useful in improving the performance of LADAR in weather. Another example is to use non-linear optical devices to convert the return pulse to a wavelength region where better detectors are available, thus improving the signal-to-noise ratio of the electronic signal produced. Such a device might allow the use of eyesafe (> 1.5 micron) laser outputs, while leveraging the excellent performance characteristics of silicon detectors (which have a cutoff around 1 micron). There are many possibilities for transceiver designs that utilize various non-linear devices to achieve novel imaging LADAR approaches. Desirable characteristics include compact designs appropriate for non-laboratory environments, eyesafe operation, multiple wavelength operation, and wavelength tunable output. Proposals need not investigate every component

of a system concept (e.g. electronics, scanner, etc.), but should address how the transceiver design could be implemented in a complete LADAR system. LADAR system concepts should be appropriate for at least laboratory breadboard use to ranges on the order of 1 km or greater.

PHASE I: Investigate the performance of the proposed transceiver through modeling, construction, and experimentation with critical elements of the proposed design. The investigation results would be incorporated into a detailed prototype transceiver design to be reported at the end of Phase I.

PHASE II:Involves the construction and delivery of a transceiver prototype based upon the design and components investigated in Phase I.

PHASE III DUAL USE APPLICATIONS: Advances in LADAR transceivers can result in new system capabilities appropriate for a variety of uses in the military and commercial sectors. Potential commercial uses include remote sensing applications for environmental monitoring, security systems, and vehicle proximity warning sensors. Potential military uses include munition seekers, airborne reconnaissance and surveillance, and targeting systems.

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KEYWORDS: LADAR, laser radar, laser ranging, non-linear optics, optical amplifiers, wavelength conversion

AF99-192 TITLE: LADAR Scene Projection for Hardware-In-The-Loop Testing

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: A real-time method to optically stimulate a LADAR seeker during closed-loop testing.

DESCRIPTION: Currently hardware-in-the-loop testing of LADAR guided munitions is accomplished through digital scene injection. Polygon models of targets and backgrounds are used to generate pixelized range data that are appropriately formatted and sequenced for digital injection into the munition signal/image processor. In the immediate future the same LADAR data will be injected in the form of time delayed optical pulses into the detectors in the LADAR seeker by by-passing the seeker optics. These methods however represent a compromise in that the test facility assumes that it knows perfectly the seeker gimbal position and body attitude position in order to synthetically generate the correct data. In addition, the injected pulses are idealized and do not accurately represent the pulse shapes characteristic of laser returns from complex targets and backgrounds.

A method is desired to optically represent time-delayed laser returns to a seeker during closed-loop weapon testing. The weapon system will provide a timing reference in the form of either a laser pulse or an electronic signal and the scene projector will provide temporally accurate laser return pulses. At a minimum, a method is desired to directly inject accurate optical signals into sensor detectors. Ideally, the seeker would be free to look anywhere within the oversized field-of-view of a projector. Data describing the time-delays and reflected pulse shapes for all points within the field-of-view of the projector will be provided by a scene generation computer based on the relative distances between scene entities and the seeker. Relative time-delay accuracy for the projector pulses must be on the order of 0.5 nanoseconds.

PHASE I: Focus on defining a LADAR projection concept that can meet the above defined objectives. Leveraging commercial off-the-shelf hardware and software solutions to support this task must be considered. Concept accuracy, limitations, and system interface requirements should be estimated.

PHASE II:Develop and demonstrate a hardware prototype of the projection concept.

PHASE III DUAL USE APPLICATIONS: LADAR Scene Projector technology could be used to greatly reduce the risk in development of complex 3-dimensional imaging systems. This class of imagining system could be used for detailed surveillance and terrain mapping by police, investigative, and search and rescue agencies or for exploration of regions by unmanned vehicles. Adequate test of these complex systems will reduce development and deployment risks and enhance commercial viability.

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2. E. M. Olsen, C. F. Coker, Real-time range generation for hardware-in-the-loop testing, SPIE Proceedings - Technologies for Synthetic Environments: Hardware-in-the-Loop Testing, April 1996

KEYWORDS: LADAR, laser radar, scene generation, scene projection, hardware-in-the-loop

AF99-193 TITLE: Fast Imaging Polarimetry

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Develop fast imaging polarimetry for detection of polarization signatures of targets and backgrounds.

DESCRIPTION: The Advanced Guidance Division of the Air Force Research Laboratory Munitions Directorate is interested in supporting the development of polarization sensitive imagers, investigating the underlying phenomenology, and characterizing polarization critical optical components. Polarization imaging holds promise for providing significant improvements in contrast in a number of target detection and discrimination applications. Polarization signatures arise from the preferential emission or reflection of light in the planes perpendicular and parallel to a target surface. Polarization signatures are dependent on the wavelength, the surface properties (index of refraction and surface roughness), external sources, and the geometry of the sensor, the surface, and the sources. In several experimental systems, significant contrast has been demonstrated that complements the conventionally imaged signature. However, these experimental systems frequently require long data acquisition times resulting in artifacts in the polarization signature due to changes in the scene. Additionally, calibration and investigation of systematic errors in these systems is difficult and robust calibration procedures have not been fully demonstrated. Proper calibration requires accurate laboratory instrumentation to characterize the full polarizing properties of the polarization critical optical components in the polarization imagers. Laboratory instrumentation is also required to better characterize target and background materials and understand the variation of polarization signatures with wavelength, geometry, and material property. The goal of the Munitions Directorate is to investigate novel imaging polarimeter concepts that measure some or all of the polarization parameters and address advanced seeker requirements for speed and sensitivity. In addition, this effort will consist of the investigation of the phenomenology that produces polarization signatures, development of calibration devices or procedures for polarizatin imaging systems, and development of instrumentation that characterizes the polarization properties of materials and critical optical components.

PHASE I: Investigate novel concepts for imaging polarimeters and design laboratory instrumentation for the characterization of polarization properties of materials and optical components.

PHASE II:Produce a prototype of the imaging polarimetric instrumentation and demonstrate the measurement capabilities in appropriate tests. Proper calibration procedures and any necessary calibration hardware should be developed and verified.

PHASE III DUAL USE APPLICATIONS: Multiple military applications include not only advanced seekers for autonomous guided munitions, but also mine detection, trip wire detection, and theater missile defense. A wide range of commercial applications can be projected including humanitarian de-mining, ice detection, machine vision, and display technology. The commercial application should be formulated during Phase I. Phase II will require a complete commercialization plan.

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KEYWORDS: retarders, polarizers, polarimetry, Stokes vector, Stokes parameters, imaging polarimeters, polarization elements, polarization signatures

AF99-194 TITLE: Visible Wavelength Scene Projection for Hardware-In-The-Loop Testing

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: A real-time method to optically stimulate a visible seeker during closed-loop testing

DESCRIPTION: Munition systems are being proposed that take advantage of signature characteristics of targets at visible wavelengths. A projection system is required for real-time representation of target images during hardware-in-the-loop testing. In hardware-in-the-loop tests a scene generation computer produces an image based on the relative position and orientation of the munition and the target. This digital information is then fed into a calibrated projection system for presentation to the munition sensor. Most recent development effort has been in the infrared wavebands. A visible projection concept is required that is flickerless, i.e., non-scanning, and has a large pixel format. Formats greater than or equal to 1024x1024 are required. Projector framerates greater than 100Hz are required. Other key parameters are uniformity, repeatability, dynamic range, and resolution.

PHASE I:The program should focus on defining a visible projection concept that can meet the above defined objectives. An initial concept demonstration is required. Leveraging commercial off-the-shelf hardware and software solutions to support this task must be considered. Concept accuracy, limitations, and system interface requirements should be estimated.

PHASE II:Develop and demonstrate a usable projection system.

PHASE III DUAL USE APPLICATIONS: This technology will allow for detailed hardware-in-the-loop test of many classes of complex vehicles that are controlled using visible sensor systems. These vehicles might include unmanned space vehicles executing docking maneuvers, or autonomous exploration and surveillance systems. The visible projector has the potential to enhance the state-of-the-art of movie projection systems for the entertainment industry by increasing dynamic range, intensity resolution, and framerate.

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KEYWORDS: scene generation, scene projection, hardware-in-the-loop

AF99-195 TITLE: Innovative Methods for Improving Strength and Fracture Toughness of Steel

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Develop innovative concepts and processes and materials for improving strength and fracture toughness of steels.

DESCRIPTION: New and innovative concepts, processes and materials are required in the area of air delivered non-nuclear munitions that will have a dual use and high commercialization potential. Current methods for improving strength and fracture toughness are generally limited to reduction of sulfur content and adding substantial concentrations of cobalt and nickel. As a result, significant improvements have been made for the required properties but they have driven the cost of steel up 6-10 times that of ordinary steel. Now that it is known that the higher performance can be obtained, concepts and processes must be developed that will drive the cost back down while maintaining the desired characteristics. Areas of research include improvements in quality control, functionally gradient materials, heat treatment, mechanical forming processes, microstructural gradient control, reduction of inclusions that cause embrittlement and development of inclusions that improve strength in concert with fracture toughness. The necessity for improvements is apparent as targets are further hardened, requirements for terradynamic steering are added and production costs continuing escalating. Military uses include bombs, penetrators, subminutions, warheads, projectiles, fuze assemblies, aircraft structures, etc. Commercialization uses include higher performance and lighter weight car and truck frames, commercial aircraft structural components, bridge structures, etc.

PHASE I: Investigate new and innovative concepts, processes and materials for improving strength and fracture toughness of steels. Develop methodology of the proposed processes and establish control parameters. Demonstrate procedures are generally applicable and yield expected results.

PHASE II: Develop and demonstrate that the proposed concepts, processes and materials are valid and that the results are approaching properties established for materials such as HP9-4-20 up to AF-1410. Develop mechanical properties data base for supporting hydrocode development and produce one-quarter prototype penetrators.

PHASE III DUAL USE APPLICATIONS: This exploratory development program has extremely high utility for both the military as well as the commercial sector. Military tactical program objectives of increased penetration, terradynamic steering and reduced costs will benefit from the improved mechanical properties. Military aircraft developers will have greater latitude in design of weapon bays and deployment options by utilizing smaller, more efficient weapons. Commercial steel users such as aircraft manufactures, automotive producers and bridge contractors will have new materials available for new design that are more efficient and cost effective.

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KEYWORDS: HLSA, steel, cobalt, hardening, low sulfur, Inclusions, yield strength, tensile strength, fracture toughness

AF99-196 TITLE: Innovative Techniques for Laser Radar

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Develop new techniques and components for imaging laser radars

DESCRIPTION: Develop laser radars or laser radar components based on techniques which promise a substantial performance improvement and/or cost reduction over current laser radar (LADAR) systems. Laser radars are useful tools for a variety of commercial and military applications. Current long-range LADAR systems rely on one of two basic schemes for finding the distance to an object: a pulsed direct detection scheme which measures the photon time-of-flight, or a scheme which measures distance based on coherent mixing of an intensity modulated output and/or return. Each of these schemes has drawbacks and limitations. For example, direct detection devices typically use single element detectors (especially at wavelengths greater than one micron) that must be scanned in order to produce 3D imagery. Slow scanning results in low imagery frame rates. Improving LADAR performance over the state-of-the-art can be accomplished either by improving the components that make up a current LADAR system, or basing a system on a new technique for range measurement. Likewise, reducing the cost of LADAR systems may be achieved through component cost reduction, or designing new systems that are inherently cheaper than existing ones. This topic invites proposals that pursue any of these paths. Proposals should address research into a new or lower-cost component for use in an existing LADAR scheme, or research into a new technique expected to result in improved performance or reduced system cost. Current LADAR components include lasers, optical detectors, optical scanners, transmit and receive optics, and ranging electronics. Techniques which lend themselves to implementation in compact packages are of great interest. Furthermore, techniques and components that can be used at near-IR to mid-IR wavelengths may allow more eyesafe operation of LADAR systems. Exploration of multi-spectral LADAR components and systems is encouraged. Proposals need not cover every aspect of a LADAR system design, but should contain enough information to make clear how the proposed component or technique fits in to a LADAR scheme that is appropriate for imaging targets at distances on the order of 1 km (or greater). Proposed schemes should be appropriate for implementation in at least a laboratory breadboard setup.

PHASE I: Investigate the performance of the proposed component or technique through modeling, construction, and experimentation with critical elements of the proposed design. The investigation results will be incorporated into a detailed prototype component or LADAR system design to be reported at the end of Phase I.

PHASE II:Phase II of this project would involve the construction and delivery of a prototype component or LADAR system based upon the design developed in Phase I.

PHASE III DUAL USE APPLICATIONS: Advances in LADAR systems and components can result in new system capabilities appropriate for a variety of uses in the military and commercial sectors. Potential commercial uses of LADAR systems include remote sensing applications for environmental monitoring, security systems, and vehicle proximity warning sensors. Potential military uses include munition seekers, airborne reconnaissance and surveillance, and targeting systems. Advances in individual LADAR components may result in a wide variety of commercial and military applications, depending upon the particular component and the nature of the advance. Lasers, optical detectors, and optical scanners have many uses in a wide range of commercial and military systems.

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KEYWORDS: LADAR, laser radar, laser ranging, direct detection, optical scanners, optical detectors, laser applications, coherent laser radar

AF99-197 TITLE: Electron Bombardment Charge Coupled Devices (EBCCD) Development for LADAR Applications

TECHNOLOGY AREA: Sensors

OBJECTIVE: Investigate new EBCCD materials and architectures for use in imaging LADAR receivers

DESCRIPTION: The Air Force Research Laboratory Munitions Directorate has been involved in the research and development of LADAR seeker technologies suitable for air-to-air and air-to-surface munitions. Recently, increased emphasis has been placed on using high-speed, two-dimensional detector arrays to gather range and intensity images. The use of a detector array enables high (e.g. video) frame rates and reduces or eliminates mechanical scanning requirements for certain short range applications. Our LADAR receiver architectures require two essential operating characteristics of a candidate receiver array: frame rates (i.e. array read out rates) greater than 30 Hz, and gain modulation at MHz rates. We currently have LADAR systems which use an image intensifier tube that illuminates a commercially available silicon CCD array to achieve these two characteristics. The image intensifier gain can be modulated at MHz rates, while the CCD can be read out at video rates. However, for munition seeker applications, it is desirable to eliminate the image intensifier tube to save on space, cost, and improve seeker durability. Furthermore, current image intensifier/CCD architectures are limited to operation in the visible spectrum, resulting in LADAR systems that are not eyesafe. Recent advances in Electron Bombarded CCD (EBCCD) technology have made it an attractive candidate for use in LADAR receivers. Since the photocathode material is an intrinsic part of the device, it would eliminate the need for an image intensifier tube in a LADAR receiver architecture. In EBCCD devices, gain modulation can be achieved by modulating the photocathode voltage. The underlying silicon CCD array should allow for video read out rates. This topic seeks proposals that would conduct research and development into EBCCD technologies, ultimately leading to the fabrication and delivery of an EBCCD device for use in a LADAR receiver. Such a device should have an array of at least 256x256 pixels, a frame rate of 30 Hz or better, and the ability to modulate the gain at a 10 MHz rate. Proposals are encouraged that would investigate novel photocathode materials for EBCCD operation at near-IR wavelengths between 1.0 and 2.5 microns.

PHASE I: Investigate the performance of the proposed EBCCD through modeling, construction, and experimentation with critical elements of the proposed design. The investigation results would be incorporated into a detailed prototype EBCCD design to be reported at the end of Phase I.

PHASE II: Phase II of this project would involve the construction and delivery of an EBCCD prototype based upon the design investigated in Phase I.

PHASE III DUAL USE APPLICATIONS: Advances in EBCCD technologies can lead to a variety of military and commercial imaging applications. Passive imaging applications include night vision and low-light level video monitoring. Commercial active (i.e. LADAR) imaging applications include remote sensing for environmental monitoring, security systems, and vehicle proximity warning sensors. Potential military LADAR applications include munition seekers, airborne reconnaissance and surveillance sensors, and targeting systems.

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KEYWORDS: LADAR, EBCCD, laser radar, laser ranging, detector arrays, optical detectors, Electron Bombarded CCD

AF99-204 TITLE: Advanced Rocket Propulsion Technologies

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop innovative components, manufacturing/processing techniques, and integration technologies aimed at doubling existing rocket propulsion capabilities by the year 2010.

DESCRIPTION: There is a critical need for novel, innovative approaches to develop technologies which can double existing rocket propulsion capabilities by the year 2010, and for bold, new, nonconventional aerospace propulsion-related technologies which will revolutionize aerospace propulsion in the next century. These revolutionary concepts, based on sound scientific and engineering principles, are essential in order to increase performance and mission capability while either maintaining existing or decreasing life-cycle costs. The proposed solutions shall emphasize "dual use technologies" that clearly offer civilian/commercial as well as military applications. Proposals emphasizing "spin-on technology transfer" from the civilian/commercial sector to military applications will receive additional consideration.

Our technological goals include: 1) Improve specific impulse and mass fraction for boost and orbit transfer, spacecraft, and tactical missile propulsion. 2) Reduce the stage failure rate and hardware and support costs for boost and orbit transfer propulsion. 3) Improve the thrust-to-weight ratio for liquid rocket engines. 4) Improve the total impulse to wet mass ratio for electrostatic and electromagnetic satellite propulsion systems. 5) Improve density impulse of monopropellants for satellite propulsion systems. 6) Improve the delivered energy of tactical missile propulsion systems. In the conduct of rocket propulsion research we strive to reduce environmental hazards from propellant ingredients and processing, propulsion exhaust, and rocket motors while either maintaining or surpassing current propulsion efficiency.

Improvements in the operability, reliability, maintainability, and affordability of space launch applications, might include development of novel systems which can be launched with short lead times for a relatively low life cycle costs. Such a concept may include the design and development of a rocket-based combined cycle (RBCC) engine. Such systems would need to demonstrate high reliability and maintainability levels.

Subsets of advanced rocket technologies would have lengthy shredouts of potential research subjects but are not stated here in detail. These technologies might include the need for innovative combustion and plume diagnostics (i.e., application of electro-optical devices and sensors), performance predictions, modeling of exhaust plume radiation and combustion characterization, propellant and component service life prediction technologies, and environmental contamination.

Additionally, bold, new advanced propulsion and related technological concepts and products for space activities are solicited for development. These topics include revolutionary concepts in advanced fuels and oxidizers, metastable high energy nuclear states, storage of antimatter in chemical matrices, nanotechnology products and techniques applied to rocket propulsion, enigmatic energy devices, and field propulsion thrusters. Research in these advanced rocket propulsion topics are included and structured to provide a maximum of innovative flexibility while yielding promising commercial applications/dual-use technology applications to prospective investigators.

PHASE I: Further develop the concept and perform analyses required to establish the feasibility of the proposed approach.

PHASE II:Complete the Phase I design and develop a demonstrator or prototype. Document the R&D and develop a technology transition and/or insertion plan for future systems and commercial ventures.

PHASE III DUAL USE APPLICATIONS: Advanced rocket propulsion technologies will transition to new, higher performing and/or lower cost U.S. military and commercial rocket engines and motors or advanced propulsion systems. This will enable the U.S. aerospace industry to increase global market share for space launch opportunities by reducing the life-cycle cost and increasing the efficiency of inserting payloads in orbit. Advanced rocket propulsion technologies also serve the commercial sector by enhancing our ability to remanufacture components to maintain and monitor the health of the U.S. ballistic missile fleet.

REFERENCES: "Selected Bibliographies, Handbooks, Manuals, and Reviews," CPIA SB-94, Nov 1994 (CPIA, 10630 Little Patuxent Parkway, Suite 202, Columbia, M.D. 21044-3204)

KEYWORDS: Rocket Plume, Rocket Engine, Rocket Propellants, Advanced Propulsion, Satellite Propulsion, Boost and Orbit Transfer

AF99-205 TITLE: Aero Propulsion & Power Technology

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Explore innovative approaches for turbine and advanced propulsion systems and electrical power concepts for manned and unmanned applications.

DESCRIPTION: The Aero Propulsion & Power Directorate aggressively pursues major performance advances in all components of gas turbine engines under the Integrated High Performance Turbine Engine Technology (IHPTET) initiative. Technologies derived under this initiative have resulted in higher thrust to weight ratios and improved efficiencies. The focus of this topic is to consider those aspects in the design of gas turbine engines and other prime propulsion concepts, electrical power systems and energy storage devices that could support manned and unmanned mission requirements. The innovative approaches may include, but are not limited to, the use of microelectromechanical (MEMS) and mesoscopic machine technology. Emphasis would be on affordability, reliability, and lightweight designs without compromising range and payload. New analysis techniques, innovative designs, hybrid

propulsion systems and electrical power concepts to support manned and unmanned air vehicle (UAV) applications are solicited.

PHASE I:Define the proposed concept and predict the performance of the proposed design. Explore the feasibility of a new concept or concepts, through analysis and/or small scale testing to demonstrate the merits of a flexible modular design that can meet various mission applications.

PHASE II:Provide detailed analytical derivations and prototypical device or hardware demonstrations.

PHASE III DUAL USE APPLICATIONS: UAVs can present an effective alternative for some civil sector missions, for example meteorological data gathering, atmospheric sampling and surveillance. Forest Service mapping and fire spotting, agriculture and ranching support, coastal and border patrol and surveillance, and storm tracking and disaster assessment are some specific areas that may be exploited with UAV

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KEYWORDS: MEMS, fuels, scramjets, lubrication, power systems, turbine engines, mesoscopic machines, High speed propulsion

AF99-206 TITLE: Directed Energy Weapon Power Technology

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop electrical power system concepts and relevant technology such as electrical power generation, power electronic conversion, energy storage (including batteries, capacitors and flywheels) and pulsed power for potential directed energy weapon systems concepts. Perform related computer analysis and simulation to understand overall component and system performance.

DESCRIPTION: The Air Force seeks innovative concepts for electrical systems, electrical power generation, power electronic conversion, and pulsed power conditioning for electrically powered directed energy weapon (DEW) concepts for potential tactical, theater, and national missile defense systems. The types of DEW systems considered in this program include high power microwaves devices, solid-state diode laser, gas lasers, radio-frequency based free electron lasers, and radio-frequency based particle beams. The power levels of these potential vehicle systems range from 100's kW up to 100's MW average power. The voltages in these systems range from 100's V for solid state based systems up to 100's kV for microwave and radio frequency based systems. The turbine generator technologies of interest in this program range from permanent magnet and switch reluctance generators at the low power range to superconducting magnet generators at the higher power levels. Direct energy conversion technologies such as magnetohydrodynamic (MHD) and electrohydrodynamic (EHD) generators will be evaluated for these platforms. The magnetic technologies of interest include light weight permanent magnets, switch reluctance electromagnets, and lighter weight superconducting magnets. The power electronic technologies of interest in this effort include cryogenically cooled components, high voltage semiconductors switches and diodes (1000's V), high voltage pulsed power switches (100's kV), high energy inductors, high voltage insulators (100's kV), and high energy capacitors (10's kJ). Computer analysis and simulation software development that combines computational fluid dynamics, thermodynamics, with magnetohydrodynamics and electrohydrodynamics equations will be important in this effort. Reduced ordered system computer models of the different generators, power converters, and pulse forming devices will be developed as part of this effort. Thermal management technologies for the systems and battery technologies will be evaluated as part of this effort.

PHASE I: Define the technical problem, identify a proposed solution, demonstrate component hardware technologies, or develop conceptual designs of components and systems.

PHASE II: Develop prototype component hardware or the detailed designs of components and systems with computer simulation software that demonstrate the performance of the system.

DUAL USE APPLICATIONS: Software and component technologies will have potential commercial applications for high power and high voltage generators and power electronics used in utility power systems, and civilian space missions.

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2. O. Mueller, K. G. Herd, Ultra-High Efficiency Power Conversion Using Cryogenic MOSFETs and PESC 1993 Conference Proceedings, pp 772-778.
3. Berry, G. Users Manual for MGMHD: A Multi-Grid 3D Code for Analysis of MHD Generators and Diffusers, Argonne National Laboratory Report MHD/89/1, IEEE 24th Annual Power Conference, IEEE Sctvice Center, Piscatawy NJ. NASA Technical Report 90N16526, NTIS-DE 90004453.

KEYWORDS: capacitors, electric power, Power generation, thermal management, electrohydrodynamics, magnetohydrodynamics, superconducting generators

AF99-207 TITLE: Micro-System Technologies for Advanced Aerospace Vehicle Power Systems

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Demonstrate the pervasive use of Microelectromechanical Systems (MEMS) technologies in aerospace power systems.

DESCRIPTION: There are many challenges in transitioning Microelectromechanical Systems (MEMS) technologies to specific applications that will benefit in cost, weight, manufacturing, reliability, etc. MEMS devices to date have had limited evolution from novel micro-devices to specific applications such as micro-sensors. For the most part, the development of micro-sensors such as accelerometers, pressure sensors, and the like have been the primary focus for transitioning this micro-technology to real world applications. Barriers to applying MEMS technologies in specific applications other than micro-sensors have been; (a) gaining access to fabrication facilities and (b) combining the diverse technical expertise required to leverage MEMS technologies to a variety of applications. The use of innovative micro-systems integral to aerospace vehicle prime power and secondary power systems must be widened, which will result in system level benefits. These innovative micro-systems may incorporate, but not be limited to, such approaches as micro sensing for diagnostic surveillance, micro-fluidics for thermal control, or microscale control of macroscale processes. These systems for current and future aerospace vehicles.

Proof of concept for microscopic batteries to provide power for MEMS applications has been shown by previous work. One of the focuses of this topic is to consider the integration of microscopic power sources, such as batteries, fuel cells, solar cells, etc., directly into actual MEMS devices. Innovative devices may include existing battery technology or include new couples or batteries specifically designed for microscopic or MEMS applications. Such devices may include, but not be limited to, any couple, any physical state (solid, liquid or gas), or any electrolyte. Emphasis would be on affordability, reliability, and operation over a wide range of temperature, pressure, and vibrational conditions, as well as manufacturability and integration potential with MEMS devices.

PHASE I: Include a feasibility demonstration, either analytical or experimental, of the proposed micro-system concept, address integration issues, and provide sufficient analysis to demonstrate prime power system or secondary power system level payoffs.

PHASE II: Include sufficient demonstration of the proposed micro-system concept to show integration viability into an aerospace vehicle prime power system or secondary power system.

PHASE III DUAL USE APPLICATIONS: The development, demonstration , and integration of robust micro-systems into aerospace vehicles represents numerous technical challenges requiring innovative solutions which in turn can be directly applied in the military and private sectors.

REFERENCE:
1. Ameel, T.A., Warrington, R.O., Wegeng, R.S., and Drost, M.K., 1997, "Miniaturization Technologies Applied to Energy Systems," Energy Convers. Mgmt., Vol. 38, No. 10-13, pp. 969-982.
2. Feasibility of Micro Power Supplies for MEMS, P.B. Koeneman, I Busch-Visniac, and K. Wood, Journal of Microelectromechanical Systems, Vol 6, No 4, (1997), 355-362.

KEYWORDS: MEMS, sensors, batteries, actuation, fuel cells, motor control, flight control, micro-fluidics, electric motors, power generation, power electronics, thermal management

AF99-208 TITLE: UAV Electrochemical Propulsion Power and Energy Storage

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop lightweight, long duration electrochemical propulsive power and energy storage systems for UAV flight platforms.

DESCRIPTION: This topic seeks proposals with innovative concepts related to electrochemically powered (batteries and/or fuel cells) unmanned aerial vehicles (UAVs). Electrochemical propulsive power and energy storage systems are sought since they can provide lightweight, cost-effective, low-observable solutions to the power/energy storage needs for UAV platforms. The power requirements can range from several watts for microelectromechanical systems (MEMS) to tens/hundreds of kilowatts for large high-altitude long-endurance (HALE) reconnaissance/directed energy weapons platforms. The mission times range from several hours/days for primary power applications to months/years for solar regenerative applications. Rechargeable energy storage capacities greater than 250 watt-hours/kilogram are desired. Electrochemical propulsive power weight goals are mission dependent, however, doubling the energy density compared to existing propulsion systems is the desired goal.

PHASE I: Define the proposed concept, predict the performance of the proposed design, and through analysis and sub-scale testing, demonstrate that the proposed design can meet the desired weight goal for the UAV mission application.

PHASE II:Provide an operable prototype component or system that is completely suitable for the intended application. The prime consideration must be deliverable hardware and a clear demonstration of a manufacturable device, component or system that improves the existing technology either through exceptionally high performance, significantly reduced cost, or improved robustness.

PHASE III DUAL USE APPLICATIONS: Electrochemical batteries and fuel cells for UAV's would be utilized in civilian UAV's, electric vehicles, and various other portable power applications.

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1. P.B. Koenenman, I.J. Busch-Vishniac, and K.L. Wood, Feasibility of Micro Power supplies for MEMS, Journal of Microelectromechanical Systems, Vol. 6, No. 4, Dec 97, pp355-362.
2. K.C. Reinhardt, T.R. Lamp, and A.J. Colozza, Solar-Powered Unmanned Aerial Vehicles, 31st International Energy Conversion Engineering Conference, Washington DC, Aug 11-16, 96.
3. S.F. Brown, The Eternal Airplane, Popular Science Magazine, V. 244, 4 Apr 94, p.70.
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KEYWORDS: UAV, fuel, cell, power, battery, energy storage, electrochemical

AF99-209 TITLE: Power Generation and Thermal Management

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop techniques, devices and components for aerospace power generation and thermal management/control.

DESCRIPTION: Electrical machines are needed that operate at high speeds (30-70 krpm) while generating power up to 300 kW for Auxiliary Power Unit (APU) and main engine applications. A machine running at higher speed can usually attain a higher power density and lower weight. However, a high power density motor or generator poses difficult technical challenges generally associated with the generation of high heat loads from magnetic and electrical losses and windage. Proposals are solicited which offer ways to either reduce these heat loads, or to ameliorate their effects. Examples of areas of interest include, but are not limited to, high temperature windings and potting materials (>400 degrees C, 600 degrees C goal) for switched reluctance machines (SRMs), fault tolerant winding configurations for permanent magnet (PM) generators, non-lubricated active or passive rotor suspension systems (including hybrids) for APUs, and on-line diagnostic approaches for monitoring/controlling APU rotor/bearing system stability.

Innovative thermal management concepts are sought in the areas of high power electronics and rotating machine cooling. More Electric Aircraft (MEA) power system components possess unique environments which preclude conventional cooling approaches. Concepts that integrate the cooling and electronics package are desired for their effective and compact nature. In general, passive concepts are desired over active concepts. Passive thermal management concepts for high performance aircraft have the potential of being reliable and simplistic in design, and are therefore preferred. However, such concepts must manage the inherent coupling of transient heat generation and transient acceleration-induced forces, and their effects on the cooling performance of the device. When active cooling is proposed, air is the most desirable coolant while existing aircraft fluids such as JP-8 fuel, polyalphaolefin, or MIL-standard lubricants will suffice if the cooling system is conceived as a line replaceable unit (LRU) or is modular. Reduction of Life Cycle Costs (LCC) should be a key objective for all efforts. For air cooling, low pressure drop

approaches that are integral with the electronics package are desirable. The effects of altitude or the impact of the use of compressor bleed air must be addressed when air cooling is proposed. Areas of interest include but are not limited to, two-phase cooling, immersion cooling, heat pipes, heat exchangers with enhanced heat transfer surfaces, and the use of micro electro-mechanical systems (MEMS) to control and enhance interfacial heat transfer.

Other concepts are sought for selecting and demonstrating materials which offer the potential of both ac and dc superconducting operating capability at liquid nitrogen temperature, in magnetic fields greater than three tesla, and at current densities greater than 100,000 amps per square centimeter. Cryogenic power converters are needed which are compatible with aircraft voltage of 270 Vdc, operate at temperatures of 77-150K, demonstrate efficiencies of 99% or better, and demonstrate power densities greater than 1,600 watts per cubic inch at power levels above 300 kW. High voltage aircraft technologies include innovative approaches for system insulation, high electric field dielectrics and insulation aging characterization. Concepts are also sought involving electromagnetic effects, including the assessment of the survivability/vulnerability of More Electric Aircraft (MEA) circuits to both manmade and natural electromagnetic threats.

PHASE I: Develop a detailed technical definition of the problem, identify a proposed solution, and demonstrate the key technologies enabling the use of that solution.

PHASE II: Concentrate on development of prototype components, subsystem demonstrations, and hardware development.

PHASE III DUAL USE APPLICATIONS: These technologies have application for all high speed motors, generators, actuators, and power electronics which may be used in future high power density electric/hybrid transportation vehicles (commercial air, high speed rail, and electric car), power generation, and manufacturing facilities.

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1. "Prediction of Windage Power Loss in Alternators," NASA TN D 4849, James E. Vrancik, NASA Lewis Research Center, Oct., 1998, N68-37162, NTIS, 5285 Port Royal Road, Springfield, VA.

2. "High Temperature Generator Development," AFAPL TR 74 69, Robert Fear, et al., Westinghouse Electric Corporation, AD-786 046; NTIS, 5285 Port Royal Rd., Springfield, VA.

3. "Cooling Down Hot New Electronics," Leland, J.E., Price, D.C., Hill, B.P. and Collicott, H.E., Aerospace America, Vol.33, No.6, pp. 40 44, 1995.

KEYWORDS: Power generation, actuator cooling, thermal management, electronics cooling, fault tolerant PM machines, switched reluctance machines

AF99-210 TITLE: Advanced Dielectrics and Capacitor Devices

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop innovative dielectric materials and/or capacitor devices with superior electrical and thermal properties over the current state of the art in one or more of three distinct and different thermal operating environments:

(1) -55 degrees C to > 300 degrees C
(2) 20K to 240K
(3) -55 degrees C to 125 degrees C

DESCRIPTION:
High temperature power electronics systems will be a pervasive technology in the next generation of weapon systems. Typical power systems include motor drives, inverters and converters for switched reluctance starter/generator systems, dc to ac inverters, dc to dc converters, and pulse forming networks. Common to all of these systems are capacitors, which are numerous, and are critical to the operation of the system. Today's capacitors are the weakest link in power electronic system reliability and are currently limited in temperature capability to a maximum of 125 degrees C. Current application temperatures range from -55 to 200 degrees C and some applications may require > 300 degree C operation with superior electrical performance. Attention to lowering the leakage currents, lowering the dissipation factor, increasing the voltage breakdown strength and increasing the dielectric constant over the current state of the art is desired. For integrated passives, attention to lowering the dissipation factor and leakage currents is paramount. Candidate proposals shall address novel and innovative high temperature dielectrics and/or high density packaging and/or manufacturing technologies to reduce cost. A large range of specific uses include dc and ac power filtering, energy storage, high repetition rate (pulse power) devices, high energy back-up or hold-up power devices, and small signal (SMT, MCM, etc.) capacitor applications for controls.

Cryogenic capacitor devices operating in the More Electric Aircraft (MEA), specifically in the temperature range of 20K to 240K, are of interest. These cryogenic systems include capacitor devices in motors, generators, power conditioning and distribution circuits and energy storage networks (PFN), etc. The same superior electrical properties are desired for the cryogenic area as listed for the high temperature environment.

For electrochemical capacitor device development, the proposal can focus either on energy density or power density, or both objectives can be addressed. Energy density should exceed 250 J/cm3 while the peak power density should exceed 30 W/cm3. An equivalent series resistance below 10 m should be an objective, as should improved cycle life (>1 million cycles). An optional objective could also be the increase in maximum cell voltage (above 2.5 V). Power electronics development proposals will also be entertained which deal with chargers/converters designed to meet the unique characteristics of electrochemical capacitors and that pertain to any of the applications listed in this topic.

PHASE I: Demonstrate innovative capacitor approaches with substantial improvement in capacity, dielectric constant, voltage breakdown strength, dissipation factor, and temperature capabilities. Prototype laboratory capacitors should be fabricated and tested to demonstrate the feasibility of the technology.

PHASE II:Demonstrate development of prototype capacitor components using innovative dielectric material or advanced high density packaging or manufacturing technology or a combination thereof. Actual application testing should be performed and electrical, thermal and life assessments made.

PHASE III DUAL USE APPLICATIONS: Capacitors are used in nearly every commercial and military system that consumes electrical power. Potential applications include all consumer electronics, medical electronics including defibrillators, automotive electronics including electric vehicles and electric utilities. High temperature applications include aircraft engine ignition systems and electrical actuation, deep oil well instrumentation, and under the hood automotive applications.

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3. Peters, A., "Power Capacitors - New Developments," IEEE Colloquium on Capacitors for Inductors for Power Electronics," IEEE, London UK, 1996.
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KEYWORDS: capacitors, electrodes, Dielectrics, pulse power, electrolytes

AF99-211 TITLE: Integral Superconducting Electrical Power Generator for Rocket Turbopumps

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Conduct analysis to determine viability of replacing existing pneumatic and hydraulic rocket engine control systems and/or boost pumbs with electrically powered superconducting based systems. Address issues of cost, weight, reliability, and maintainability. Demonstrate the technologies required to integrate a superconducting electrical power generator into cryogenic rocket engine turbomachinery.

DESCRIPTION: Modern aircraft gas turbine engines routinely use shaft power to generate electrical power for the host aircraft. Current rocket engines use separate auxiliary power units to provide power to hydraulic systems which actuate valves or use stored gas systems to power pneumatically actuated valves. In either case, a weight and volume penalty is incurred due to the need to provide power to control system actuators. The availability of a significant source of electrical power would allow for the use of smaller, lighter-weight electromagnetically actuated valves. Elimination of hydraulic or pneumatic systems would also eliminate control system specific leaks and simplify control system maintenance and health monitoring.

PHASE I: (a) Consult with cryogenic rocket engine manufacturers and users to identify potential rocket engine electrical power requirements based on the potential electrical power users identified above. (b) Conduct a survey of superconducting materials and generators to determine the viability of the concept of a light weight, compact, high power superconducting generator at temperatures typically found in cryogenic turbomachinery. (c) Identify requirements for an integral superconducting electrical power generator for rocket turbopumps. (d) Consult with cryogenic rocket engine manufacturers and prepare conceptual designs to fulfill the identified requirements. (e) Among competing conceptual designs, select the most promising and initiate a preliminary design. (f) Prepare a test plan to demonstrate the validity of the design in a simulated cryogenic turbopump environment.

PHASE II: (a) Finalize the design selected in Phase I. (b) Manufacture prototype test hardware. (c) Conduct testing in a simulate or actual cryogenic rocket propellants using test plan developed in phase I. (d) Review results of testing and consult with cryogenic rocket engine manufacturers and users. (e) Identify any prototype modifications needed to meet established requirements. (f) Conduct market analysis to determine marketability of product and identify market base/competitors. (g) Modify design as required. (h) Re-accomplish testing as required and create manufacturing plan.

PHASE III DUAL USE APPLICATIONS: Any technology developed for military spacecraft can also be used in commercial spacecraft. These technologies also have wide application in terrestrial systems, such as hybrid or all electric vehicles, remote site power, building/home secondary power supplies, and power plants. The primary military application is to reduce satellite power system mass, volume, and cost to increase payload mass and power budgets and reduce satellite and launch vehicle costs.

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3. Public information available from vendors such as Reliance Electric of Cleveland, OH on the internet at http://www.reliance.com/prodserv/motgen/b2776_1.htm

KEYWORDS: Electric APU, Cryogenic APU, Rocket Propulsion, Superconducting APU, Cryogenic Generator, Electrical Generator, Auxiliaray Power Unit, Superconducting Generator, Superconducting Electric Generator

AF99-212 TITLE: High Performance Oxidizer System for Hybrid Missiles

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop and demonstrate an environmentally clean, non-toxic, high performance oxidizer system for use in hybrid tactical missiles. The tactical thermal environment is -65oF to +165oF

DESCRIPTION: A recent Air Force Research Laboratory study demonstrated that missiles using hybrid propulsion have the potential to make significant gains in performance over more conventional approaches. In hybrid propulsion, unlike a solid rocket motor, fuel and oxidizer are separated until mixed in a combustion chamber. Innovative approaches are needed to create oxidizers and expulsion systems that meet requirements for future missiles systems. These requirements demand systems which are able to perform in extremes of temperature, are non-toxic and safe, behave as insensitive munitions, and are capable of high performance. In tactical missiles, high performance entails both high density and high oxidizing capability. Oxidizer systems that can meet these standards, whether they are gelled liquids, slurries of liquids and solids, or some other innovative combination, are vital to improved performance in future missiles.

PHASE I: Develop and characterize the oxidizing chemical to be used in the hybrid missile. The candidate oxidizer would first be screened theoretically to verify that it has the potential for the high performance needed in a tactical system. It is expected that the oxygen balance, toxicity, storability, and hazards of the material would be determined through laboratory analytical techniques. The suitability of this chemical relative to tactical requirements would then be determined. Once the basic nature of the oxidizer is determined, a conceptual design of the oxidizer expulsion system would be undertaken. As a result of Phase I of this effort, the awardee would have produced and demonstrated, in the laboratory, a promising oxidizer and have an initial design of an oxidizer expulsion system for hybrid tactical missiles.

PHASE II:The volume of chemical oxidizer produced would be scaled up to quantities suitable for testing in tactical motors. A low cost synthesis method would be demonstrated. The expulsion system designed in Phase I would be built and tested. The expulsion rate, pressure, spray characteristics, and efficiency would be measured. At the end of this phase, a live firing of a tactical size hybrid motor using the oxidizer system that was developed and a suitable fuel would be expected.

PHASE III DUAL USE APPLICATIONS: The results of a successful Phase II program would result in technologies that would find a wide variety of commercial uses. Car airbags and other safety devices represent a large market that needs similar ability to deploy gases quickly and efficiency. Other commercial products include various combustion devices such as torches, welders, emergency generators.

REFERENCE:
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KEYWORDS: Rocket, Hybrid, Oxidizer, Propellants, Expulsion system

AF99-213 TITLE: Solar Thermal Rocket Propulsion

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop novel solar thermal propulsion components and technologies.

DESCRIPTION: The solar thermal rocket propulsion concept is to develop and Orbit Transfer Vehicle (OTV) to perform the mission of boosting payloads from low earth orbit to geosynchronous orbit (GEO). An OTV based on a high specific impulse solar rocket engine has the ability to deliver twice the payload to GEO as current chemical upper stages. Solar rocket engines generally consist of two paraboloid reflectors which concentrate sunlight into a small high temperature heat exchanger. Hydrogen gas is heated by flowing through the exchanger and produces thrust by accelerating out a nozzle.

To be practical for AF missions, the mass and packaging volume of the OTV must be kept to a minimum. This has led to the use of thin film inflatable concentrators and suppoprt struts that deploy and rigidize once in orbit. The concentrators consist of two films attached at the edge to form a clamshell. The first film simply holds the very low pressure gas against the second film that is the reflector. To make this type of reflector viable, it must be able to deploy and maintain a shape to a fairly tight accuracy. It must also have sufficient stiffness to be controllable and be resistant to the space environment. This includes micro-meteroids, atomic oxygen, and UV radiation. Novel ideas such as methods to rigidize the thin film are needed to provide 30-day life requirement. Other areas of interest are ways to keep the films from tearing, ways to self seal punctures, ideas to keep wrinkles fron forming during packaging, and ways to fine tune the support struts once in orbit. There is also a need for a method of measuring or sensing the shape and accuracy of the concentrator once deployed. This would allow a space experiment to deploy an inflatable reflector and determine the shape and optical path qualities including reflectivity, vibrations, wrinkling, shape error, pointing errors, and support effects.

Another major component ripe for innovative solutions is the high temperature heat exchanger. Operational systems need to run between 2000K and 3500K. This presents the challenge of designing and manufacturing a device which can operate at the temperature, be compatible with hydrogen, and provide hundreds of cycles and hundreds of hours of operation over a 30- day mission. Furthermore, the design must get as much of the energy to the propellant as possible. This requires very good high temperature insulation, a very small entrance aperature to the exchanger, a high ratio of absortivity to emissivity, or a design that can perform efficiently without one of those. Generally, a secondary optic is placed at the entrance aperature to further concentrate the incoming sunlight. Although its smaller size makes weight less of a concern, the reflectivity is very important and it must operate at moderately high temperatures or be designed to operate cool in close proximity to the high temperature exchanger. Due to the multi-impulse burn profile of the solar OTC concept, a heat storage device can have attractive benefits. Hence, novel ideas concerning high temperature heat storage such as phase change materials are also of interest. There are issues needing attention which concern the ground testing of these engines. A method is needed to remotely monitor the surface temperature of the high temperature heat exchanger. This includes both the chamber and nozzle temperatures as viewed from down stream, and the absorbing surface of the exchanger which is flooded by intense sunlight. Furthermore, a characterization of the velocity profile of the exhaust plume is needed since the very small nozzle throat has significant influence on the flow.

PHASE I: Analyze the design or idea and perform tradeoffs. Factors to be considered should include ease of use and ability to manufacture, effectiveness of solving targeted problem, cost, reliability, efficiency, and overall benefit to the Air Force goal of developing a high ISP, light weight solar rocket. The most promising designs and methods should be validated by laboratory demonstrations or by detailing how state of the art technology is sufficient for the application.

PHASE II:Further develop, design, fabricate, and demonstrate the chosen Phase I design/concept/method. The advantage and performance of the manufactured components should be evident or be designed to be easily tested and proven by the contractor or government. The contractor shall deliver any hardware/software developed, document the work performed and develop a plan for technology transition and insertion into future systems and other commercial ventures.

PHASE III DUAL USE APPLICATIONS: The high temperature materials, thin film materials, and their manufacturing processes developed under this program will be useful for many civilian products developed by diverse industries at significant cost savings. For example, automotive, power plant, and refining industries need high temperature materials to prolong the life and reduce the cost of many products. The thin film precision materials and processes have many space applications where weight and volume are significant concerns.

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Technical MEMO 87650, NASA-Langley Research Center, December 1985.

KEYWORDS: Concentrators, Black Body Cavities, Direct Gain Absorbers, Solar Thermal Propulsion, Cryogenic Propellant Tanks, Geosynchronous Orbit (GEO), Orbit Transfer Vehicle (OTV)

AF99-214 TITLE: Electric propulsion thruster for low power small satellites

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop and validate innovative design concepts for low power electric propulsion thrusters applicable to small satellites.

DESCRIPTION: Small satellites are extremely mass and power limited. In addition, propulsion system requirements for this class of satellite will be high due to: larger maneuvering requirements, higher precision attitude control, increased stationkeeping life, and higher drag make-up for low orbit satellites. Substantial improvements in both thruster performance and specific power are needed to provide this increased propulsion system capability while constrained by large mass and power limitations. The objective of this effort is to radically push the technological envelope in the field of electric propulsion. Proposed concepts must show promise of more efficiently utilizing the on-board electrical energy while maintaining high specific impulse operation. Projects proposing enhancements to existing systems will also be considered. The propulsion system should be sized for satellite masses from 500 lbm down to 10 lbm with satellite specific powers from 1 to 4 W/kg.

A strong emphasis should be placed on the validation of the design that is expected to provide the stated performance enhancements; experimental and theoretical methods can be considered. Government and commercial test and evaluation facilities may be utilized; documentation of efforts to secure these facilities should be provided. Based on the results of these tests, thruster performance should be estimated and improvements quantified.

PHASE I: Develop innovative electric propulsion thruster concepts and validate critical design features for small satellite (500 lbm to 10 lbm) applications: primary interests are performance, thrust-to-weight ratio, minimal impact on spacecraft operations and systems, minimal spacecraft contamination, environmental compatibility, and lifetime. The focus of the effort should be on stationkeeping and orbit maneuvering applications.

PHASE II:Apply the results of Phase I to the design, fabrication, experimental validation, and optimization of EP thruster performance capabilities. The design process is expected to be iterative with the thruster with the best overall performance being reproduced and be deliverable at the end of the Phase II period.

PHASE III DUAL USE APPLICATIONS: Dual use commercialization would occur through the development of flight quality electric propulsion systems for small satellite and space experiment applications. The development of small satellites, and their propulsion systems, is one avenue for reducing satellite launch costs. The higher performance thrusters will result in greater mission capability including both satellite life and maneuverability, which are areas of interest to government and commercial customers. Both mission capability and profitability will increase through the introduction of these thrusters into the marketplace. The outlook for commercialization therefore appears very strong.

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KEYWORDS: Ion Engines, Service Life, Stationkeeping, ARC Jet Engines, Specific Impulse, Performance Tests, Electric Propulsion, Electrothermal Engines, Electromagnetic Propulsion

AF99-215 TITLE: Cryogenic Boost Pump with Integral Superconducting Electric Motor

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop novel superconducting boostpump components and technologies for cryogenically fueled aerospace vehicles.

DESCRIPTION: Boost pumps are required to avoid cavitation in high-speed turbopumps fed from low pressure, lightweight vehicle tanks. Typical rocket engine boost pumps require high pressure propellant lines to supply the turbine drive fluid which adds weight

and complexity to the engine system. This could be avoided through the use of a tank-mounted electrically driven boost pump. The source of power for such a boost pump might be a generator mounted on the main turbopump which could use a superconducting current path running along the cryogenic propellant lines to feed the boost pump motor. Use of an electrically driven superconducting boost pump could reduce overall system weight, volume, and provide numerous other system benefits.

PHASE I: (a) Consult with cryogenic rocket engine manufacturers and users to identify boost pump requirements. (b) Prepare conceptual designs to fulfill the identified requirements and identify the payoffs and liabilities of each design. (c) Evaluate all conceptual designs and select the most promising for further development. (d) Prepare a test plan to demonstrate the validity of the design in a simulated cryogenic turbopump environment.

PHASE II: (a) Finalize the design selected in Phase I. (b) Manufacture prototype test hardware. (c) Conduct testing Magnetohydrodynamics in simulate or actual cryogenic rocket propellants using test plan developed in Phase I. (d) Review results of testing and consult with cryogenic rocket engine manufacturers and users. (e) Identify any prototype modifications needed to meet established requirements. (f) Conduct market analysis to determine marketability of product and identify market base/competitors. (g) Modify design as required. (h) Re-accomplish testing as required and create manufacturing plan.

PHASE III DUAL USE APPLICATIONS: Advanced boost pump technologies will transition to new, higher performing and/or lower cost U.S. Military and commercial rocket engines or advanced propulsion systems. This will enable the U.S. aerospace industry to increase global market share for space launch opportunities by reducing the life-cycle cost and increasing the efficiency of inserting payloads in orbit and moving payloads among different orbits. Advanced boost pump technologies may also serve the commercial sector by enabling the ability to remanufacture satellites already on orbit.

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2. Superconducting Technology Program, Sandia 1993 Annual Report, SAND94-1279 (NTIS, 5285 Port Royal Road, Springfield, VA.
3. Public information available from vendors such as Reliance Electric of Cleveland, OH on the internet at http://www.reliance.com/prodserv/motgen/b2776_1.htm

KEYWORDS: Boost Pump, Cryogenic Motor, Rocket Propulsion, Electric Boost Pump, Rocket Engine Boost Pump, Superconducting Electric Motor

AF99-216 TITLE: Innovative Design of Pulse Detonation Engines

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop design methodologies for innovative pulse detonation propulsion devices.

DESCRIPTION: The Pulsed Detonation Engine (PDE) is widely recognized as a promising concept for aerospace transportation that can revolutionize propulsion in the next century. The PDE is considered advantageous for a wide range of propulsion applications ranging from boosters and upper stages through interceptor divert engines to micro-propulsion for spacecraft and Unmanned Air Vehicle (UAV's). Such devices offer a range of potential advantages compared with traditional deflagration based propulsion systems, e.g., simplicity (few moving parts), low cost (through modular design), high performance with a wide range of fuels, high thrust-to-weight (no high pressure pumps and compressors), high turn down ratio, simple thrust vectoring, no requirement for exotic materials etc. Although a number of such devices are currently being fabricated and tested, validated design methods and scaling laws for PDE's do not exist. Nor, is there a demonstrated understanding of the parameters which control and limit achievable performance. The timely and successful development of pulse detonation propulsion devices will ultimately depend upon the resolution of these fundamental issues. This is especially true for PDE's based on liquid fuels (an attractive alternative to current gaseous-fueled systems) as the effect of fuel and injection characteristics on detonation initiation and deflagration-to-detonation transition are virtually unknown. Thus, there is a critical need for development and validation of an innovative PDE design methodology and scaling laws for multi-phase systems. In addition to combustion related issues, this methodology should also address engine/airframe integration, noise reduction, and structural loads resulting from the oscillatory nature of PDE operation. Combined with a realistic assessment of Air Force propulsion needs, a validated design methodology will enable the identification of realistic goals for new engine development, the most advantageous applications, and key technological barriers to be overcome. The proposed research shall emphasize dual use technologies that clearly offer civilian/commercial as well as military applications. Proposals emphasizing spin-on technology transfer from the civilian/commercial sector to military applications will receive additional consideration.

PHASE I: Develop an advanced design methodology for a broad spectrum of pulse detonation applications and conduct a limited bench scale validation effort.

PHASE II: Use the Phase 1 design methodology to design an innovative, high payoff propulsion device that addresses a defined Air Force mission requirement. Fabricate a sub-scale test device that represents a convincing demonstration of the ability to design a full scale system capable of meeting Air Force Requirements.

PHASE III DUAL USE APPLICATIONS: Transition device into flight weight demonstration. Explore use of design methodology to produce innovative designs that fulfill commercial sector space propulsion requirements.

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KEYWORDS: Boosters, Liquid Fuels, Pulsed Detonation Engine, Spin-On Technology Transfer, Unmanned Air Vehicle (UAV's), Pulse Detonation Propulsion Devices

AF99-217 TITLE: Multi-Mode Propulsion Technology Development

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop and demonstrate technologies for a multi-mode rocket-airbreathing propulsion system concept.

DESCRIPTION: The Air Force is interested in the performance potential and inherent simplicity of multi-mode propulsion systems. The technology area has usually been represented by Rocket Based Combined Cycle (RBCC) engines, also known as Air Augmented Rocket engines. Pulse Detonation Propulsion (PDP) technologies also may be ideally suited for multi-mode propulsion systems. In either case, the key advantages stem from the use of a single flow path for multiple operating modes.

RBCC propulsion technologies have been demonstrated at various levels of maturity over the past few decades. Thus far, PDP technology development efforts have been conducted separately for rocket and airbreathing variants. Rocket PDP technologies are being developed for spacelift and orbital transfer applications. Airbreathing PDP technologies are being developed for very low cost propulsion systems.

A multi-mode propulsion system should combine the high thrust loading of a rocket mode with the high efficiency of an airbreathing mode. The main benefit of a multi-mode engine, as opposed to separate rocket and airbreathing engines, would be the high volumetric efficiency and low weight of a single flow path used for multiple operating modes.

Several applications appear to be suitable for multi-mode propulsion systems:

A trans-atmospheric vehicle ascending to space would launch in rocket mode, transition to airbreathing mode for atmospheric acceleration, and then revert to rocket mode for spaceflight. The airbreathing mode would also be used for atmospheric cruise after reentry from orbit.

A missile or unmanned aerial vehicle would launch and accelerate in rocket mode and then transition to airbreathing mode for atmospheric cruise. In this case, a multi-mode engine would eliminate the need for separate rocket booster and airbreathing sustainer propulsion systems.

This effort will advance the state-of-the-art of multi-mode rocket-airbreathing propulsion technologies for military applications. Successful efforts will result in the development and demonstration of technologies for the entire propulsion system, including the following key subsets:

Air induction (inlets, diffusers, compressors)
Combustion (ramburners, thrust chambers, pulse initiators, pulse detonation tubes)
Control (timing, sensors, diagnostics, operating modes)
Nozzle (manifolds, mixers, expansion surfaces or devices)
Propellant (fuels and oxidizers, preferably non-cryogenic)
Propellant system (pumps, plumbing, heat exchangers, injectors)
Structure (thermal protection, vibration control)

PHASE I: Predict the performance parameters and physical characteristics of one or more multi-mode propulsion system concepts. Evaluate these parameters against the expected values for competitive rocket and airbreathing propulsion systems. Derive technology demonstration goals for key subsets of multimode propulsion technology. Report on the feasibility of multi-mode propulsion systems.

PHASE II: A complete demonstration of the technologies for a multi-mode propulsion system will most likely require

multiple SBIR efforts. Each effort should experimentally verify the Phase I performance projections for key subsets of multi-mode propulsion technology. Demonstration efforts will probably employ ground testing in direct connect and/or freejet propulsion test facilities. Subsequent efforts would include freejet test and/or flight test of an integrated multi-mode propulsion system.

PHASE III DUAL USE APPLICATIONS: If successful, multi-mode propulsion systems will be applicable to military and civil space launch systems, trans-atmospheric vehicles, and high speed transport aircraft.

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KEYWORDS: Wave, Pulse, Engine, Rocket, Pulsed, Detonation, Aeropropulsion

AF99-218 TITLE: Nanoreinforced Plastics for Liquid Rocket Engine Components

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Application of nanoreinforced plastics for use as light weight materials for liquid rocket engines.

DESCRIPTION: Despite their high strength and light weight polymeric materials have made few in-roads into liquid rocket engines (LRE) component applications. Under the Department of Defense's Integrated High-Payoff Rocket Propulsion Technology (IHPRPT) initiative, an increase in the thrust-to-weight ratio of 60% is sought to meet Phase II program goals. While LRE's would obviously benefit from the weight savings of plastics, severe service requirements have restricted their use. Nanoreinforcement of plastics shows promise as a technology that is capable of increasing performance of existing resins to the point where they may have use in LRE's as ducting, turbine seals, shrouds, and nozzle extensions. These materials must operate over a temperature range of -200 C to 200 C, show o,ood wear resistance and have a high heat distortion temperature. In addition, these materials must be amenable to low cost manufacturing techniques.

PHASE I: Identify and synthesize nanoreinforced resin candidates for LRE ducting, seals, or nozzle extensions. Conduct sufficient testing to demonstrate the viability of the candidate materials for their specific application.

PHASE II: Optimize the material properties and demonstrate the ability to produce kilogram quantities of promising candidate materials at a reasonable cost and to fabricate components using conventional plastics manufacturing techniques. Provide test specimens with size and shape specific to AFRL's sub-scale component testing requirements.

PHASE III DUAL USE APPLICATIONS: Nanoreinforced plastics have great potential for use in the automotive, aircraft, electronics, and sports equipment industries wherever increased mechanical properties and higher use temperatures are I required.

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KEYWORDS: Ducts, Shrouds, Plastic, Polymer, Turbine seals, Nanocomposite, Nozzle extensions, Liquid rocket engine

AF99-219 TITLE: Optical Measurements in Opaque Media: Combustion Applications

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop a prototype instrument to measure the properties of optically dense combustion flows.

DESCRIPTION: Many propulsion applications of interest to the Air Force involve chemically reacting flows which are too dense for conventional optical measurement techniques. Optical obscuration can be caused, for example, by turbulence/temperature interactions that cause a large random index of refraction variations, by dense sprays that are created at elevated pressures, or by large soot radiation signatures that tend to obscure the signal of interest.

This topic seeks to take advantage of innovative new techniques that have recently been developed to perform optical diagnostics in opaque or turbid media. For instance, resonant imaging holography has been performed by tuning the light source to a resonant line of the structure to be imaged and subtracting out the non-resonant signal. Structures have been visualized inside containers of milk in this way. As another example, ballistic imaging techniques have been developed which take advantage of recent fast lasers and fast detectors, where the time of photon arrival can be correlated with the number of scattering encounters. Images have been obtained through 5mm of flesh is this latter case.

Creative ideas are sought for applying techniques including, but not limited to, these examples to optically dense combustion flows. Adapting these techniques to the special requirements of combustion is expected to require its own significant degree of innovation. Techniques are sought which are capable of measuring one or more of the following quantities: temperatures, combustion species, velocities, particle sizes, and various ratios of these quantities such as O/F ratios.

PHASE I: Should identify and demonstrate the feasibility of an innovative technique for performing a combustion measurement in an optically dense flow.

PHASE II:Should develop the concept(s) identified in Phase I into a workable prototype instrument.

PHASE III DUAL USE APPLICATIONS: Optical techniques for opaque media already have vast commercial applications. Two examples are medical imaging and airport luggage scanners. Adding the capability to perform measurements in chemically reacting flows would add a large additional market. The instrument developed under this topic would have widespread commercial combustion applications not limited to military air breathing or rocket propulsion. Examples include automotive gasoline and diesel engines, gas turbine combustors for land, sea, and air applications, fossil fueled furnaces of all types, hazardous waste incineration, other non-combustion applications involving particulate flows, and a wide range of chemical process industry applications.

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Optics, Vol. 30, No. 29, 4204-4210, (1991).

KEYWORDS: Combustion, Turbid media, Opaque media, Ballistic imaging, Optical Measurements, Resonant image holography

AF99-220 TITLE: Combustion Efficiency Measurements for Advanced Propulsion Systems

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop innovative strategies for measuring the combustion efficiency of advanced propulsion systems.

DESCRIPTION: A number of key performance parameters must be considered to evaluate the potential of advanced propulsion systems such as the pulsed detonation engine (PDE). Among these parameters are the fuel-air ratio, emissions indices, and combustion efficiency. Unfortunately the strategies currently in place for the determination of these parameters are inadequate for characterizing system performance. Combustion efficiency is a particularly difficult parameter to quantify for these advanced propulsion systems. Combustion efficiency is defined by the ratio of the energy released during the combustion process to the energy that would be realized were all the carbon in the fuel converted to carbon dioxide and all the hydrogen in the fuel converted to water vapor. Through measurements of carbon monoxide (CO), carbon dioxide (CO2), total hydrocarbons (HC), and oxides of nitrogen (NOx) in the engine exhaust, combustion efficiency can be calculated on an enthalpy basis by accounting for inefficiencies due to the production of carbon monoxide and unburned hydrocarbons. Measurements are typically achieved through gas-sampling systems that employ flame-ionization, infrared-absorption, or chemiluminescent detection schemes. Unburned hydrocarbons are treated as methane, and probe-based measurements are averaged over time at numerous locations in the engine exit plane to account for temporal and spatial inhomogeneities.

While this approach provides acceptable combustion efficiency measurements for current stateof-the-art gas turbine engines, advanced propulsion systems now under development are not adequately characterized through this measurement scheme. A number of specific measurement challenges exist. Advanced combustion efficiency measurements must address the many chemical forms assumed by unburned and partially burned hydrocarbons in the engine exhaust. Simply considering these emissions in terms

of methane leads to unacceptable efficiency measurements. Pulsed detonation engines involve cyclical operation at frequencies up to several hundred cycles per second. This transient behavior demands innovative approaches to combustion efficiency measurement. Spatial inhomogeneities at the exit plane must also be addressed to achieve meaningful measurements. As engine operating temperatures approach stoichiometric conditions, dissociation processes and equilibrium concentrations of hydrogen and carbon monoxide in the engine exhaust must be considered as well. Often the exhaust constituents to be determined are present at trace concentrations demanding highly sensitive measurement techniques. This topic seeks the development of innovative strategies for achieving combustion efficiency measurements in light of these complications.

PHASE I: Conduct research to identify strategies that provide improved measurements of combustion efficiency compared to existing state-of-the-art approaches. Once strategies are identified, perform reduced-scale laboratory experiments to explore the advantages of the proposed measurement concepts. Modeling and other computational support of proposed strategies are advantageous but not sufficient for a Phase I effort.

PHASE II:Provide complete demonstration and documentation of the performance gains associated with the proposed strategy for measuring combustion efficiency. Ideally, this demonstration should be achieved in conjunction with a combustion application of interest to the Air Force.

PHASE III DUAL USE APPLICATIONS: Combustion efficiency measurements are critical to the development of high-performance/low-emissions engines. Technologies achieved in response to this SBIR topic will have widespread applications throughout both the military and commercial propulsion industries. In addition, the fruits of this effort will impact other combustion-related endeavors including the automotive, power-generation, and wasteincineration industries.

REFERENCE: Society for Automotive Engineers Aerospace Recommended Practices 1533, "Procedure for the Calculation of Gaseous Emissions from Aircraft Turbine Engines."

KEYWORDS: Emissions, Combustion, Propulsion, Measurement, Turbine Engines, Combustion Efficiency

AF99-221 TITLE: High Heat Sink Jet Fuels, Additives and Test Methods; Chemically Reacting Fuels

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop advanced high heat sink thermally stable jet fuels, additives, improved test methods and high temperature fuel system components. Develop chemically reacting fuels which feature enhanced properties which are activated during discrete portions of the operational envelope.

DESCRIPTION: Jet fuel is a primary coolant used to cool aircraft and engine subsystems on current and future aircraft. Current jet fuels (JP-8, JP-5) break down at high temperatures to form gums, varnishes and coke that can plug fuel nozzles, afterburner sprayrings and spraybars, fuel manifolds and fuel controls. Advanced propulsion concepts can require up to 1500 Btu/lb cooling from the fuel. To provide the necessary cooling the fuel must be resistant to degradation under both autoxidative and pyrolytic conditions and may be under supercritical or controlled cracking conditions (endothermic type fuels). In order to develop advanced high heat sink fuels, new fuel additives that suppress autoxidation and pyrolysis at temperatures as high as 450 Degrees C need to be developed. New test methods are needed to simulate the behavior of fuels at supercritical or cracking temperatures that can be used to determine fuel reaction chemistry, kinetics, heat transfer as well as chemical and physical properties at supercritical conditions. Advanced computational fluid dynamic models coupled with fuel degradation chemistry and advanced high temperature fuel system component simulators are required to determine the impact of fuel degradation in advanced aircraft and engine fuel systems. Jet aircraft produce chemical emissions that can be released into the atmosphere at high altitudes. Fuel additives that can be added to jet fuels in small quantities and suppress emissions need to be developed. Advanced emissions measuring techniques that can be used with research combustors to evaluate the effectiveness of these new fuel additives are also required.

The composition of aviation fuels such as conventional Jet-A and military JP fuels is determined by specifications which are primarily based upon total operational requirements. However, both commercial and operational requirements vary as a function of time throughout a given mission. The most efficient commercial and military fuels would have enhanced properties only when required. Fuel is one of the most expensive components of the operational and support budget of weapon systems, and the primary cost of operating commercial airliners and ground vehicles. Hence, maximizing the use of available feedstocks while minimize use of specialty components to provide the desired enhanced performance has the potential of making high cost "designer" fuels affordable ($1 - $1.50/gallon range). One attractive application would be additives which generate desirable free radicals such as OH, H and O which initiate chain branching combustion reactions, and hence provide a technique to reduce ignition delay, increase combustion efficiency, and reduce undesirable pollutant emissions.

Under the present program, innovative fuel additives are sought which react in the fuel system or the combustor to enhance a specific property. Examples of fuel properties requiring tailored enhancement include higher reactivity, emissions reduction characteristics, soot suppressants, improved thermal stability, enhanced heat sink, higher energy density, greater lubricity and low

temperature supportability. The goals of Phase I are to identify suitable additives and demonstrate performance in a laboratory device such as a shock tube or benchtop fuel system simulator. A financial assessment to determine affordability must be considered. Analytical simulations should be used to screen potential additives, and use of the Major Shared Resource Center at Wright-Patterson Air Force Base is encouraged in order to successfully address the multi-scalar nature intrinsic to chemical processes. The goals of Phase II would be to demonstrate the performance of the additives at true operating conditions in large scale combustors or fuel system simulators, and assess implementation costs. In Phase III, the small business would be able to market the additives to the Department of Defense, and the transportation industry (airlines and commercial gasoline vendors).

PHASE I: Demonstrate the feasibility of the technology and to quantify the payoffs for both military and commercial applications.

PHASE II: Demonstrate the application of the technology, demonstrate a prototype of the technology, validate performance, and quantify payoffs for both military and commercial applications.

PHASE III DUAL USE APPLICATIONS: All technologies developed under this topic have both military and commercial jet fuel applications due to the similarities of the jet fuels (i.e. JP-8 is commercial Jet A-1 fuel with a military additive package).

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KEYWORDS: Fuels, Additives, Heat Sink, Thermal Stability, Thermal Management, Advanced Proppulsion, Chemical Reacting Fuels

AF99-222 TITLE: Advanced Instrumentation and Simulation Technology for Ramjet/Scramjet Combustors

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop instrumentation and computational fluid dynamic methods for measurement/simulation of subsonic and supersonic combusting flows.

DESCRIPTION: Obtaining accurate measurements of various flow parameters in a combusting flowfield without disturbing the flow is a difficult task. Various optical "flow" diagnostics techniques are currently under development for eventual use in the harsh environments of direct connect and free jet facilities. The need still exists for the development of new techniques to allow accurate point or field measurements of velocity, temperature, density, fuel concentration, and the consistency of the exhaust effluence in hydrocarbon and hydrogen fueled ramjet and scramjet propulsion systems. These techniques are also vital to the development of CFD simulation software. Software development requires that accurate and precise measurements be performed concurrently with and in a complimentary fashion to algorithm development and physical model validation. Shortcomings exist in the simulation of chemical kinetics, turbulence, turbulence-chemistry interaction, multi-phase flow, unsteady effects and acoustic phenomena. New robust miniature instrumentation is required to assess the performance of potential subsonic and supersonic ramjet combustors and various flow path components in free jet and direct connect facilities. In particular, the development of micro-scale high frequency sensors for measurements of wall pressure, temperature, skin friction and heat flux capable of surviving high enthalpy (up to Mach 8) flight conditions is desirable. Single- and multi-element addressable micro-opto-mechanical sensors are required for engine health monitoring and flow control. These sensors shall require minimal pre- and post-test calibration. The development of measurement techniques must coincide with the development of simulation techniques to ensure that the physical quantities needed by software developers are measured to the required level of accuracy. Simulation technology development should focus on chemical kinetics, multi-phase flow, and temporal and/or spatial resolution of the small-scale fluctuations found in 3d chemically reacting flows typical of ramjets and scramjets.

PHASE I: Develop and refine measurement techniques and instrumentation concepts in conjunction with CFD software to allow proof of concept and demonstration of relevance in representative subsonic and supersonic flows with and without heat release.

PHASE II:Develop the instrumentation and associated measurement techniques and validate the CFD software to the point where they can be used in realistic combustor temperature and pressure environments of direct connect and free jet facilities.

PHASE III DUAL USE APPLICATIONS: Potential for dual use is great. Similar if not identical instrumentation and measurement techniques are required in automotive, ground power generation, incineration, and the aerospace industries. Commercial success

is, however, dependent on ensor/instrumentation durability, practicality, accuracy, and cost. There is a great market in the US and abroad for commercialization of micro sensors and optical instruments. Similarly CFD/simulation techniques developed under this topic could be marketed to the automotive, ground power generation, incineration, and the aerospace industries.

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KEYWORDS: Micro-Scale Sensors, Addressable Sensors, High Frequency Sensors, Miniature Instrumentation, Ramjet/Scramjet Combustors, Micro-Optic-Mechanical Sensors

AF99-223 TITLE: Gas Turbine Engine Compression System Concepts

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Advance aerodynamic and mechanical technology of compression systems and secondary gas path systems.

DESCRIPTION: Future compression systems will be demanded to pack more performance into smaller, lighter, more affordable configurations. Advanced designs are utilizing highly loaded, low aspect ratio, complex shape airfoils in multistage configurations. However, increased loading produces larger blade wakes, resulting in significant aerodynamic and aeromechanical interactions between stages. In addition, increased loading has produced stall margin and efficiency sensitivity to blade tip clearance levels. Aerodynamic and aeromechanical design capability does not fully account for the unsteady interactions, the effects of wakes due to complex airfoil shapes, or the sensitivity to tip clearances that exist in compression systems. Advanced measurement methods that improve the understanding of these phenomena are desired. In addition, innovative concepts that exploit an understanding of these phenomena are needed to meet the demands of future compression systems. Areas of prime technical importance include: endwall, wake and secondary flows; time unsteadiness, advanced data analysis; forced response and mistuning.

Obtaining precise secondary gas path flow control will play an increasingly larger role in optimizing engine efficiency, as further gains in the major engine components become more difficult to achieve. Understanding primary and secondary gas path interactions can be critical to the performance of both. Reducing parasitic leakage and seal deterioration, while minimizing air needed for cooling, ventilation, and thrust balancing, is a significant challenge as the secondary gas path environment becomes more extreme. In addition, it is now anticipated that the cycle operating temperatures will dictate that cooled cooling air will be needed to maintain mechanical integrity in the turbine, and most likely in the compressor as well. Innovative concepts and models leading towards precise secondary gas path flow control are desired. Areas of particular interest include primary/secondary gas path interaction, film riding seals, trenching and shrouds, innovative thrust balancing, counter-rotation, and disk pumping.

Clear paths for incorporation into advanced military engine designs and design systems must be shown for each of the technology concepts proposed. Teaming arrangements with major engine contractors are highly encouraged.

PHASE I: Phase I will result in demonstration of feasibility of the concepts for the development of advanced compression system or secondary flow system design.

PHASE II:Phase II will result in bench tested technology concepts for advanced compression system or secondary flow system design, adequately documented to be acceptable to the technical community.

PHASE III DUAL USE APPLICATIONS: The improvements gained in compression and secondary gas path system performance and efficiency are directly applicable to both military and commercial gas turbine engines.

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KEYWORDS: Fans, IHPTET, Compressors, Unsteady Flow, Clearance Flow, Measurement Techniques, Secondary Gas Path Systems, Aircraft Gas Turbine Engines

AF99-224 TITLE: Gas Turbine Engine Combustion Instability Prediction

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop a multi-dimensional computational method that can effectively resolve unsteady fluid dynamics with heat release effects

DESCRIPTION: Future high performance gas turbine engines will be designed to provide high thrust to weight operations over a wide range of operating conditions. This will require higher overall operating equivalence ratios, higher through flows and axial flow velocities, and higher inlet and exit temperatures and pressures. Combustor performance will also require improve stability over the entire operating flight envelope. The probability of having combustion driven instability in these advanced combustors are far greater than for the existing gas turbine combustors. Combustion driven instability involve fuel-air fluctuations, produce axial, tangential and radial modes of instability and could severely impact the engine performance and its structural integrity. Accurate determination of the time scales involved in dynamic instability is an important aspect for designing stable combustors that eliminate or damp the instabilities. Numerical methods to predict the onset of combustion driven instability are very helpful in passive and active combustion control. Current combustor design systems lack the capability of identifying acoustic coupling of these unsteady combustion processes.

PHASE I: Perform an in depth analysis to identify the causal physics of combustion driven acoustic resonances in gas turbine combustor environments and develop a methodology to predict the various modes of instability with combustion.

PHASE II: Implement methodology obtained in Phase I and demonstrate its effectiveness as applied to current combustion systems design practice.

PHASE III DUAL USE APPLICATIONS: The result of this technology will enable the characterization of the impact of unsteady combustion processes on the life and performance of all gas turbine engines, including those of military and commercial aircraft, and power generation.

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KEYWORDS: IHPTET, Frequency, Heat Release, Unsteady Pressures, Multi-phase Combustion

AF99-225 TITLE: Gas Turbine Engine Turbine System Technology - Aerodynamics and Cooling

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop concepts for improving aerodynamic performance of turbine components.

DESCRIPTION: Proposals should address the development of aircraft engine turbine component technologies in the area of aerodynamics and aerodynamics test methods. A major trend in turbine components for aircraft engines is increased aerodynamic loading and reduced tip leakage flow. Efficient technology advances in these areas, improved experimental test methods and instrumentation for study state and/or short duration research facilities are also required.

PHASE I: Explore the feasibility of new concepts through development of conceptual hardware, software, or small scale testing to demonstrate the potential merits of the concept.

PHASE II: Provide detailed analytical derivations, prototype and/or hardware for full scale high speed rig testing.

PHASE III DUAL USE APPLICATIONS: Higher performance turbine engines and associated technologies will lead to more efficient, quieter and environmentally acceptable propulsion systems. Turbine technology improvements play a major role in military applications and there is great potential to transition to commercial use.

REFERENCES:

1. "Upgrading Jet Turbine Technology," Michael Valenti, Mechanical Engineering, V.117 n.2 Dec. 1995, pp 56-60.
2. "Progress Towards Understanding and Predicting Convection Heat Transfer in the Turbine Gas Path," Robert J. Simoneau and Frederick F. Simon, International Symposium on Heat Transfer in Turbomachinery, Athens, Greece, August 1992, NASA-TM-105674, (N92-26690/7) NTIS, 5285 Port Royal Rd., Springfield, VA.

KEYWORDS: IHPTET, Airfoils, Film Cooling, Aerodynamics, Computational, Heat Transfer, Fluid Dynamics, Turbine

AF99-226 TITLE: Gas Turbine Engine Control of Smart Components

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Investigate and develop the architecture, interface, and device conceptual design for control of turbine engine smart components.

DESCRIPTION: The next generation of turbine engines will employ micromechanical systems that sense and adapt to changing conditions. They are often referred to as smart systems because of the use of local processing and feedback. This contrasts with state-of-the-art (SOA) systems, which may operate open loop, or use feedback from parameters sensed at a distance, such as is done in modern engine control. Implementation of these strategies will significantly improve the performance of future engine components, such as the compressor, combustor, and turbine, including the fuel system. With smart effectors, high performance is achieved through coordination of large numbers of small sensors and actuators, rather than mechanical precision. They also are expected to provide substantial payoffs in terms of cost, weight, and volume required for a given functionality. Actuator size and power requirements are expected to decrease by a factor of 10, compared with SOA technology. Development of high temperature piezoelectric and optic materials for MEMS sensors and actuators is ongoing. However, a major concern with the development and implementation of these systems is the lack of suitable control paradigms. Investigation and development of control strategies that scale to systems with hundreds of sensors and actuators are desired. Consideration should be given to the following areas: modes of communication (including modes of propagation, signaling protocols, and interfacing) sensor and actuator architecture, energy distribution and requirements, and algorithms for processing and coordinating the synchronized operation of hundreds of actuators.

PHASE I: Investigate conceptual designs for control of a smart engine component. The control system will have an application to a realistic engine component such as a fuel valve, stationary vane, or compressor blade.

PHASE II:Design and fabricate a prototype control system based on the component and strategy investigated in the Phase I effort.

PHASE III DUAL USE APPLICATIONS: Commercialization potential for both military and commercial turbine engines.

REFERENCES: "A State Space Modeling and Control Method for Multivariable Smart Structural Systems," R. Butler, R. Vittal, Journal of Smart Materials and Structures, August 1996, Vol.5, #4.IOP (UK)

KEYWORDS: IHPTET, Sensors, Controls, Propulsion, Fuel Systems, Smart Controls

AF99-227 TITLE: Gas Turbine Engine Life Extension through Advanced Control Modes

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Investigate and develop new turbine engine control modes for turbine engine life extension.

DESCRIPTION: Recent development efforts have established the foundation of model-based control for turbine engines. In the implementation of these concepts, a simplified model (simulation) of the engine system is included in the feedback path of the control loop. Through proper adjustment, the model can be made to match the actual plant in terms of certain key parameters. Thereby, values of interest (not necessarily sensed values) can be computed by the model and made available for feedback purposes. It is believed that the theory and practice of model-based control can be extended to manage the life of engine rotating components, particularly in the core (compressor, combustor, and turbine). An important benefit of this approach is that changes to the engine and its control to accommodate a life-extending mode of operation will be relatively modest. It is anticipated that significant operational cost benefist can be achieved. Additionally, engine performance would not be affected during these modes of operation. Investigation of new engine control modes which vary the operating parameters and extend the life of the rotating machinery while meeting mission requirements are desired. Consideration should be given to the incorporation of the actual mechanical (material properties), environmental, and sensor constraints of a realistic combustor or turbine in the control design.

PHASE I: Investigate conceptual control modes for turbine engine life extension. These modes should address the life extension of the individual core components (compressor, combustor, and turbine). In addition, control modes that extend the overall life of the core should be considered.

PHASE II:Develop methodologies for the design and implementation of the life extending control modes.

PHASE III DUAL USE APPLICATIONS: The work described here would be directly transferable to commercial turbine engine applications.

REFERENCES:
1. Tracking Filter Selection and Control Mode Selection for Model-Based Control, AIAA-94-3204. S. Adibhatla and Z. Gastineau. Presented at the 30th Joint Propulsion Conference, Indianapolis, Indiana.
2. Engine Health Monitoring System for Gas Turbine Engines, Dr. Michael J. Roemer and
Dr. Neville F. Reiger, Stress Technology, Incorporated, Rochester, New York. USAF Aircraft Structural Integrity Program (ASIP) Conference, San Antonio, Texas. Printed in Conference Proceedings WL-TR-97-4055, pp. 793-806, (ADA 32755)
3. Real-Time Engine Health Monitoring and Diagnostics for Gas Turbine Engines, Michael J. Roemer and Ben Atkinson, Stress Technology, Incorporated, Rochester, New York. USAF Engine Condition Monitoring Workshop, San Diego, California.

KEYWORDS: IHPTET, Control, Materials, Model-based, Turbine engine, Life extension, Health monitoring

AF99-228 TITLE: Gas Turbine Engine Non-Intrusive Instrumentation

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop a non-intrusive surface-pressure and/or -temperature mapping technique and demonstrate it during an engine test.

DESCRIPTION: The development of electro-optical devices (charge-coupled device cameras) and fiber optic communications has enabled the development of optical pressure and temperature sensing schemes. In accordance with the Air Force's High-Cycle Fatigue (HCF) program, the ability to obtain global pressure maps of a rotating airfoil under unsteady dynamic loads are of particular interest. The pressure-sensitive paint (PSP) technique has shown great promise for such measurements in state-of-the-art fans. One technical challenge that remains is the development of advanced probes to image PSPs in an engine where optical access is very limited. Also, the desire to utilize the technique in latter compressor stages and in the turbine introduces a second technical challenge: the maximum temperature capability of PSPs.

PHASE I: To develop a state-of-the-art probe detection system to utilize the decay-time characteristics of PSPs. Initial goals would be for demonstration in an advance fan where temperatures up to 450 F are expected and frequency responses on the order of 10 kHz are required. Proposals on innovative non-intrusive surface-pressure or |temperature mapping techniques are also welcome. Under this phase the system should demonstrate the ability to acquire steady state measurements from rotating machinery and the potential to acquire transient data on the order of 10 kHz.

PHASE II:Develop and demonstrate the system ability to acquire transient surface pressures (10 kHz) from a state-of-the-art fan. The system should also show the potential to be used for higher temperatures (1300 F) and frequency responses (40KHz).

PHASE III DUAL USE APPLICATIONS: The development of a system to acquire 2D decay times (lifetime) of pressure-sensitive paints will have wide spread impact on the aerodynamic community. Such a technique will save millions by providing the required diagnostic tools to reduce the design cycle of not only engines, but aircraft and automobiles. The experimental data can be used to improve computational codes that in turn can reduce required test time in the design phase.

REFERENCES:
1. Gruber, M. R., Nejad, A. S., and Goss, L. P., "Surface Pressure Measurements in Supersonic Transverse Injection Flowfields," AIAA Paper No. 97-3254, 33rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Seattle, WA, 1997.
2. Liu, T., Johnston, R., Torgerson, S., Fleeter, S., and Sullivan, J., "Rotor Blade Pressure Measurement in a High Speed Axial Compressor using Pressure and Temperature Sensitive Paints," AIAA Paper No. 97-0162, 33rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Seattle, WA, 1997.
3. Navarra, K. R., et al, "Optical Measurements of Surface Pressure and Temperature in Turbomachinery," presented at the 90th AGARD PEP Symposium on Advanced Non-Intrusive Instrumentation for Propulsion Engines, October 1997.

KEYWORDS: IHPTET, Gas turbine, Instrumentation, Chemical sensing, Optical diagnostics, Thermographic phosphors, Pressure-sensitive paint

AF99-230 TITLE: Electromagnetic Effects and Reliability of High Power/Pulsed Power Systems

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop techniques that provide protection to high power components and sub-systems from manmade and natural electromagnetic effects and increase operational reliability of such systems in both transient and steady-state modes.

DESCRIPTION: This solicitation seeks proposals with advanced and innovative concepts related to protecting aerospace high power systems from the effects of electromagnetic threats such as the short term and long term results of electromagnetic interference (EMI), electromagnetic compatibility (EMC), high intensity radiated fields (HIRF), lightning, and partial discharge/corona. The protection concepts and the technologies involved should address advanced aerospace electric power systems that are not only critical for aerospace vehicle operation but also provide high power and pulsed power for advanced weapon systems, surveillance, and countermeasures. Technology areas of interest are novel applications of electrical insulation in extreme environments: low pressure (<0.001 torr), high temperature (>600 C), low temperature (< 70K), and corona discharge effects. Diagnostics are needed to evaluate and predict insulation system performance in high EMI environments (pulsed or continuous). The special power systems that require smaller total volume will benefit from dielectrics which will operate reliably at high electric field stresses, thus enabling high voltage components and subsystems in less space. Additional technology areas of interest are development of electromagnetic shielding, capable of providing electromagnetic effects protection to components and sub-systems from the operational characteristics of high power and pulsed power systems for aerospace vehicles and protection from external electromagnetic threats, such as HIRF and lightning. Again, the proposed research should focus on providing reliability and integrity for aerospace vehicle systems that require higher power and smaller volumes than what is currently available.

PHASE I: Develop a detailed technical definition of the problem, identify a proposed solution, and demonstrate the key technologies enabling the use of that solution.

PHASE II: Concentrate on development of prototype components, subsystem demonstrations, hardware and software development.

PHASE III DUAL USE APPLICATIONS: All of the technologies developed under this topic can be transitioned to commercial aerospace vehicles and similar systems for ground vehicles and ships, as well as ground facilities.

REFERENCES:

1. More Electric Aircraft Goals, Air Force Research Laboratory Web Site, http://www.pr.wpafb.af.mil/divisions/prp/programs/mea/mea.htm
2. Proceedings, 11th IEEE International Pulsed Power Conference, Baltimore, MD, June 1997.
3. Proceedings, 10th International Symposium on High Voltage Engineering, Montreal, Canada, August 1997.
4. Proceedings, International Aerospace and Ground Conference on Lightning and Static Electricity, Williamsburg, VA, September 1995.
5. Proceedings, IEEE International Symposium on Electrical Insulation, Baltimore, MD, June 1992.

KEYWORDS: High Power, Pulsed Power, Electric Power, Electromagnetic Effects, Electromagnetic Interference, Electrical Insulation Materials

AF99-235 TITLE: Advanced Receiver Integration By Utilization Of Correlator Output

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop and evaluate innovative GPS receiver architectures with enhanced navigation accuracy and anti-jam performance.

DESCRIPTION: Current Global Positioning System (GPS) receivers utilize a tracking loop based design. Under this system, the correlator data is fed into the tracking loops where it is processed into pseudorange and delta pseudorange measurements. These tracking loops make no use of the inter-satellite statistical properties of phase, frequency, and delay processes. As a result, the system loses performance in the reference waveform alignment process. When the GPS signal power is rapidly varying, this loss is further amplified and can even lead to an Inertial Measurement Unit (IMU) bias state contamination. Also, as a result of the post loop observables, the observables are non-white. This forces the IMU update rates to be slower than GPS loop aiding rates and detracts from the coupling with an IMU. By implementing an approach to use the correlator data directly in the Kalman filter, these inherent weaknesses of the current tracking loop design should be avoided. In this effort, the contractor will develop and demonstrate a method to achieve this correlator output use in the Kalman filter directly, thus eliminating the conventional tracking loops. The contractor shall also develop a Virtual GPS Receiver Environment (VGRE), which receives perturbed RF signals from AFRL/SNAR's

Antenna WaveFront Simulator (AWFS), downconverts and samples these signals to whatever frequency is specified by the algorithm, and monitors performance.

PHASE I: The contractor will develop a combined demodulation and navigation algorithm to perform the functions in the Kalman filter. The algorithm will be tested via simulation to evaluate performance improvements in jamming environments and vehicle blockage situations as well as standard trajectories.

PHASE II: The contractor will construct and evaluate a prototype system with the algorithm running in a signal tracking processor. Also, a sensitivity analysis to IMU quality will be performed along with definition of GRAM/SAASM interface. The algorithm will communicate with this host receiver's P/Y code correlator bank and demonstrate achieved performance improvements. The evaluation will be carried out with radio frequency (RF), IMU, and VGRE simulation tools provided by the contractor and the AWFS at AFRL/SNAR.

PHASE III DUAL USE APPLICATION: Correlator output utilization in the Kalman filter will drastically improve the robustness of both the military and civilian receivers to interference. As interference in the GPS frequency band increases, the need for improved resistance to jamming will become significant for all users of GPS. This technical effort will build the system to be used in Air Force platforms and a modified version for civilian use to reduce interference effects.

REFERENCES:
1. Sennott, J.W., Senffner, D., "Comparison of Continuity and Integrity Characteristics for Integrated and Decoupled Demodulation/Navigation Receivers," Proceedings ION GPS-95, September 1995.
2. Sennott, J.W., Senffner, D., "Robustness of Tightly Coupled Integrations for Real-Time Centimeter GPS Positioning," Proceedings ION GPS-97, September 1997.

KEYWORDS: Multiple Antenna, GPS Signal Tracking, Receiver Tracking Loops, Receiver Processing Algorithms, Modeling, Simulation & Analysis, Inertial Navigation/GPS Integration

AF99-236 TITLE: Evaluation And Demonstration Tools For Multi-sensor Fusion Technologies

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop automatic target recognition algorithm evaluation and demonstration tools for multi-sensor/multi-platform environments.

DESCRIPTION: In a multi-sensor and/or multi-platform environment, data from various sensors will be shared and fused. The ATR performance will depend on the quality of the individual sensor data and the accuracy of the accompanying reference information. AFRL/SN has funded algorithm development, evaluation and, flight demonstrations of sensors for both onboard and off-board information fusion scenarios. We are interested in receiving proposals in two subtopic areas: 1) on developing tools to capitalize on the information uncertainty and; 2) on developing evaluation and simulation tools to assist in the demonstration of fusion algorithms. The reference system subtopic would focus on the proper combining of sensor data to enhance the geo-location/geo-registering of information. The referencing information may include but is not limited to position, velocity, attitude, pointing data, and quality or uncertainty information about the data. Primary task would be to develop a practical means to capitalize on the information uncertainty that may or could be available from sensors and their host platforms and utilize it in the fusion/ATR process. Various laboratory experiments will determine the best means to characterize, extract, format, transmit, share, and use uncertainty information in the fusion/ATR process. The algorithm evaluation subtopic would focus on developing low-level simulations as a means to evaluate multi-sensor ATR performance, simulate fusion ATR performance in the SN laboratories, and use this information to assist in designing flight demonstrations. Tools using simulated data to show parametrically how sensor quality effects overall system performance are of interest. The contractor should investigate the use of simulated and/or hybrid data to investigate the algorithm operation over mission parameters for which measured data has not been collected. Image truthing and scoring tools which shorten algorithm evaluation timelines and increase the accuracy of performance measurement are also considered important to this effort. More advanced tools should examine system-of-system performance sensitivities to sensor and algorithm performance, to reference and geo-registration capabilities, and to problem complexity. All tools should be operable in the SNA laboratory environment.

PHASE I: The reference system subtopic should focus on trade-off analyses to determine the best means to characterize, extract, format, transmit, share, and use uncertainty information in the fusion/ATR process. The algorithm evaluation subtask should emphasize the development of truthing and scoring tools as well as the design of advanced tools or work should be focused at surveillance and fighter applications. Data from the Theater Missile Defense Eagel Smart Sensor Automatic Target Cuer (TESSA) program will be made available to the contractor.

PHASE II: Develop advanced simulation tools to include UAV and advanced fighter scenarios. These tools should also involve at least a subset of the processes of collecting, registering, combining, and identifying information from various sources for

a marketable commercial application. This system or tool set could take on many different forms depending on the application(s), sensors, sources, information, and processing, which is being focused upon.

PHASE III DUAL USE APPLICATIONS: These include any process requiring correlation of information from disparate sources, each having its own degree of precision and reliability and its own approach for representing the quality of that information. Potential application areas would include those requiring immediate determination of "situation awareness" such as transportation, environmental or natural disaster monitoring.

REFERENCES:
1. Keydel, Eric R., Lee, Shung W., Moore, John T., "MSTAR Extended Operating Conditions:, A Tutorial," Proceedings of the International Society for Optical Engineering (SPIE) Vol. 2757, 1996.
2. E. Zelnio, F. Garber, L. Westerkamp, S. Worrel, J. Westerkamp, M. Jarratt, C. Deardorf, P. Ryan, "Characterization of ATR Systems", Algorithms for Synthetic Aperture Radar Imagery IV, Proc. SPIE 3070. Vol 3070.
3. T. Ross, E. Zelnio, L. Westerkamp, T. Burns, "Extensibility and other Model-Based ATR evaluation Concepts", Algorithms for Synthetic Aperture Radar Imagery IV, Proc. SPIE 3070. Vol 3070.
4. Berning S., Howe P., Jenkins,T. "Theater-wide reference Information Management", Proceedings of The National Aerospace and Electronics Conference (NAECON) 1996

KEYWORDS: Radar, Tracking, Infrared, Multi-Sensor, Modeling, Simulation And Analysis

AF99-237 TITLE: Laser And Radar Clutter Characterization

TECHNOLOGY AREA: Sensors

OBJECTIVE: Characterization methodology for Laser and Radar sensors to support false alarm rate reduction and estimation.

DESCRIPTION: False Alarm Rate (FAR) reduction and estimation is an issue of growing importance for Automatic Target Recognition (ATR). A methodology is needed for characterizing clutter (i.e., any non-target region of an image) as part of solving both the FAR reduction and estimation problems. Proposals are sought for innovative methods of characterizing clutter from air-to-ground Laser Radar (Ladar) or Synthetic Aperture Radar (SAR) sensors. Ladar is of special interest for initial exploration of clutter characterization methodologies because of its high discrimination potential and relatively simple phenomenology. SAR is of special interest because of a substantial ATR technology base and the readily available measured and synthetic data. Proposers are encouraged to consider target sets that focus on military ground vehicles. The characterization of clutter is expected to depend on the sensor, the feature suite, and the target set of interest ("clutter" is, after all, defined as "not-target"). Challenges associated with FAR reduction include large variability in the target class images (e.g., from configuration variations or obscuration), a large number of target classes (numbers of over 100 are of interest), and clutter that may include non-target vehicles or other man-made objects. Clutter characterization could potentially contribute to FAR reduction by allowing improved discriminant functions which may depend on a relative comparison of a test image to targets and clutter. On-line clutter characterization could also be used for parameter adaptation or decision confidence adjustments to control FAR. Challenges associated with FAR estimation include large differences between the test imagery and the conditions-of-interest in terms of topology, vegetation coverage, climatic conditions, and development. The target set, the sensor, and their variability must also be considered. Another challenge is to estimate very low FARs with a limited amount of clutter data. Clutter characterization could potentially contribute to FAR estimation by enabling models of the relationship between test images (target and clutter) and the conditions-of-interest. Successful modeling could possibly allow the development of a small "canonical set" of test clutter that could be used to predict even small FARs for a given operational scenario.

PHASE I: The Phase I effort should include a thorough statement of the problem, outlines of one or more innovative approaches towards solution, and recommendations of materials and their sources (especially data) that could be used for Phase II.

PHASE II: The Phase II effort should include the exploration of the approach or approaches defined in Phase I, including demonstrations of FAR reductions and estimations in various scenarios.

PHASE III DUAL USE APPLICATION: The Dual Use potential is limited for this topic; however, clutter characterization methods could possibly benefit air or space surveillance in agricultural or law enforcement applications.

REFERENCES:
1. L. G. Clark (Goodwon) and V. G. Velten, "Image Characterization for automatic target recognition algorithm evaluations," Optical Engineering 30(2), 147-153 (Feb. 1991).
2. The Infrared & Electro-optical Handbook, Vol. 8, Emerging Systems and Technologies, Chapter 4, Automatic Target Recognition Systems, SPIE Optical Engineering Press and Infrared Information Analysis Center.

3. SAR Public Data Web Site:
http://www.mbvlab.wpafb.af.mil/public/MBVDATA/.

KEYWORDS: Radar, Laser, Tracking, Multi-Sensor, Modeling, Simulation And Analysis

AF99-238 TITLE: Space Based Targeting Technologies

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop and enhance technologies which support the advancement of space-based targeting capabilities.

DESCRIPTION: The objective of this effort is to enhance current modeling, simulation, algorithmic, and evaluation technologies supporting space-based targeting missions. The effort is broken out into two primary thrusts as described below. A proposer may choose to address one or both of the thrusts without penalty for omission of either thrust. The first challenge, Modeling and Simulation, seeks to expand the frontier of current space-based targeting capabilities by developing and demonstrating new simulation tools which will enable improved evaluation of advanced targeting algorithms. This thrust begins with the development and demonstration of techniques to enhance the fidelity and accuracy of signature data used in modeling and simulation applications. The quality of this data is a key factor for the integrity of algorithmic and evaluation research efforts in this area; improved fidelity and accuracy of signature data may increase confidence in radar tracking and end game engagement assessments. Areas to address include signature data compression techniques, monostatic and bistatic RCS. The proposer shall modify simulation tools as necessary to utilize high-fidelity RCS data and demonstrate the payoff of using enhanced fidelity signature data. These techniques should then be used to support the development of simulation tools which facilitate critical examination of advanced targeting information issues such as fusion of data from multiple platforms and tracking of dim/low observable targets. The emphasis of the simulation phase of this effort would be to formulate appropriate metrics, design and develop simulation tools and use these to examine tradeoffs for potential application. The second challenge, Unified Tracking and classification, seeks to develop robust technologies for simultaneously detecting, tracking and classifying moving targets from measurements of kinematics and signature. We are interested in model-based approaches that offer a unified framework for stochastic estimation of track and clss together, thereby exploiting the natural link that usually exists between them, e.g. through pose-induced transformations in the signature data. Typical kinematic measurements are range and range rate and/or azimuth and elevation, while typical signature measurements include radar high range resolution (HRR) profiles that are pose sensitive. Note that imaging sensors also exhibit signature to kinematic coupling that may be exploitable in a unified estimator. The estimation technology employed should be useful against both air and ground targets (including low observable targets) in multi-target/multi-sensor scenarios. A goal of this thrust is to produce results in real-time using affordable amounts of storage and comutation power. The government will support this thrust with 1) signature data sets, both real and simulated (e.g. the MSTAR collection), and 2) a simulation engine that models aircraft dynamics as well as radar and EO sensor outputs.

PHASE I: In the modeling and simulation area, Phase I effort will include design of new modeling techniques and simulation tools, formulation of evaluation metrics, and implementation of a subset of the modeling and simulation tools that are applicable to single and multi-platform space vehicles. The unified tracking and classification work will produce a tool and a simulated result adequate to show the potential for unifying track/class estimation tools that are applicable to single and multi-platform space vehicles. Major activites of this phase include modeling, simulation construction, and testing solution attributes.

PHASE II: Phase II will entail complete development of the simulation tools and utilizing them to perform studies and trade-off analyses as dictated by the monitoring agency for the modeling and simulation effort. For unified tracking and classification, the emphasis will be to further develop the chosen approach and demonstrate its usefulness and limitations on more complete and realistic data sets and scenarios. The following issues should be examined: mix of measurement types; alternatives in phenomena modeling; effects of noise and clutter; algorithm configuration. Final products will include the simulation tool and a technical report documenting the mathematical approach (math formalisms, associated models, computer algorithms), experimental results, performance evaluation, recommendations, and assessment of future directions.

PHASE III DUAL USE APPLICATIONS: This technology has potential commercial use in search, track and identification systems such as exist in applications like air traffic control and drug interdiction.

REFERENCES:
1. J. R. Layne, "Automatic target recognition and tracking filte,", National Symposium on Sensor and Data Fusion, April 1998, Marietta, GA.
2. E. Libby and P. Maybeck, "Application of sequence comparison methods to multisensor data fusion and target recognition," IEEE Aerospace and Electronic Systems, Jan 1997, 52-65.
3. S. Jacobs and J. O'Sullivan, "High-resolution radar models for joint tracking and recognition," Proceedings of the 1997 IEEE National Radar Conference, May 1997, 99-104.

KEYWORDS: Radar, Laser, Tracking, Multi-Sensor, Modeling, Simulation And Analysis

AF99-239 TITLE: Miniaturization Of Evanescent-mode Filters

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop a Process for Miniaturization of Evanescent-Mode Filters.

DESCRIPTION: Very small high-Q evanescent-mode filters are made using very small capacitors in parallel with real or virtual inductors. The size of the filter is dominated by the size of the inductor. Therefore, one way to reduce overall filter size and weight is to reduce the amount of inductance required, and hence reduce the size of the inductor. In order to do this, the capacitance of the above-mentioned capacitors must increase. The OBJECTIVE of this project is to increase the capacitance of the capacitors in high-Q evanescent-mode filters by an order of magnitude (10X). In the current technology, single-layer thin ceramic substrates are commonly employed for developing capacitance within the very small evanescent-mode filters. Conductors on opposite sides of these thin substrates essentially form a parallel plate capacitor and hence the thickness of the substrate is inversely proportional to the capacitance. Commonly, the ceramic substrate material is alumina or quartz and current substrates are as thin as 0.003". The capacitors display Q values of at least 1000, or 3 to 4 times that of commercial multilayer capacitors. The capacitance of these devices can be increased by reducing the ceramic substrate thickness. The goal for this effort is to achieve an order of magnitude increase in capacitance, thereby requiring substrates of 0.0003" thickness. This capacitance is to be achieved at breakdown values consistent with the expected operating voltages. To build such substrates will require fabrication in place, perhaps using techniques such as Metal Organic Chemical Vapor Deposition (MOCVD), sputtering or some other evaporative process. Current MOCVD technology can be used to fabricate substrates with a thickness of 0.0001" but innovative build up layers to 0.0003" is thought to be possible. The payoff of increasing the capacitance by an order of magnitude would be an order of magnitude reduction in the above-mentioned inductor values and therefore a significant reduction in the size of the filters. A typical intermediate frequency (IF) filter (at approximately 1 GHz) weighs 1 to 3 ounces. The proposed improvement would result in filters weighing only 0.3 to 0.5 ounces. For a typical satellite payload with 500 EF filters, the total filter weight would reduce from 31 - 94 lbs to 9 - 16 lbs. Obviously, benefits associated with packaging would also be realized.

PHASE I: 1) Thorough knowledge of the limits of existing technologies, develop a plan for extending the process technology as necessary to accomplish an order of magnitude increase in the capacitance of capacitors using single-layer thin ceramic substrates, 2) Develop process plans and associated filter designs based upon the new process technology, 3) Simulate and predict the performance of a typical filter designed for fabrication by the new technology.

PHASE II:Complete detailed process/filter design and demonstrate the innovative process technology by the fabricating and testing of units capable of operation in the space environment.

PHASE III DUAL USE APPLICATIONS: The need for high-Q filter technology is continually driven by the ever-increasing crowding of the satellite communications spectrum. Therefore, improvements in such filters will benefit military, government, and commercial satellite industries. The weight reduction indicated above would hold true for both military and commercial satellite payloads.

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1. R. V. Snyder, "Generalized cross-coupled filters using evanescent mode coupling elements," IEEE-MTT Symposium, Denver, CO, June 1997, pp. 1095-1098.
2. C. Kudsia, R. Cameron, W.C. Tang, "Innovations in microwave filters and multiplexing networks for communications satellite systems," IEEE Trans. MTT, vol. 40, June 1992, pp. 1133-1149.

KEYWORDS: RF Components, Ceramic Substrate, Filters/Multiplexers, Metallization Process, Evanescent Mode Filters, Substrate Metallization

AF99-240 TITLE: Innovative High Power Microwave/millimeterwave Device Development For Military Essential Systems

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop innovative semiconductor device technology and demonstrate concept feasibility for military essential applications, such as sensors for space-based radar.

DESCRIPTION: The research will explore revolutionary new device concepts and conduct feasibility demonstration efforts on devices with potential for robust, high frequency microwave/millimeterwave applications which can function in harsh environments. This effort will examine new devices, device concepts, and advanced semiconductor fabrication technology for high efficiency linear power amplification. The addressed environmental challenges consist of high temperature and/or high radiation. The intention of this program is to examine new device approaches. this will include new and existing devices (Heterojunction Bipolar Transistors (HBTs), Metal Semiconductor Field Effect Transistors (MESFETs), and other very high performance devices), new and existing device materials (InP, InGaP, GaN) and looking into novel fabrication method to improve power amplifier performance for applications such as phased array radar (military) and wireless local area network (commercial). Selection of the demonstration vehicles shall be based on customers' future needs and the availability of suppliers transferring these technologies from a research to a production environment. This program shall be divided into two phases. Device concepts, including material development and fabrication feasibility, shall be demonstrated during Phase I. Functional demonstration vehicles and design of potential products shall be completed at the end of Phase II. It is expected that fabrication capability of commercial and military products will be established by end of Phase II.

PHASE I: Material growth, characterization, and device development shall be completed.

PHASE II: Functional demonstration vehicles and design of potential products shall be completed, such as novel active devices and power amplifiers using those devices.

PHASE III DUAL USE APPLICATON: Commercial applications include personal telecommunications systems, wireless local area network, automobile sensors/collision avoidance system, security systems, and intelligent highway systems.

REFERENCES:

1. Y.-F. Wu, "High Al-Content AlGaN/GaN MODFET's for Ultrahigh Performance" IEEE Electron Device Letters, Vol. 19, No.2, pp 50-53, 1998

2. A.T. Ping "DC and Microwave Performance of High-Current AlGaN/GaN Heterostructure Field Effect Transistors Grown on p-Type SiC Substrates" IEEE Electron Device Letters, Vol. 19, No.2, pp 54-56, 1998

KEYWORDS: Semoconductors, Microelectronics, Integrated Circuits, Solid State Physics, Heterostructure Devices, III-V Compound Semiconductors

AF99-241 TITLE: RF Photonics For Space-based Application

TECHNOLOGY AREA: Sensors

OBJECTIVE: The USAF is seeking new ideas and technology to support the distribution of Radio Frequency (RF) signals in space-based platforms.

DESCRIPTION: This effort is directed to the development of photonic components (enabling technology) which are critical to the use of photonics in hgh dynamic range, low loss, high frequency, wideband analog fiber optic links for RF signal distribution and other applications in space-based and airborne platforms such as true time delay beam formation and beam steering subsystems in phased array antennas. Issues to be addressed are one or more of the following: (1) high efficiency conversions from RF to optical and/or optical to RF; (2) minimization of throughput losses (3) transparency of the photonic RF interconnect to the RF signal by (a) low noise, (b) high dynamic range - goal of 140 dB/Hz2/3 , (c) small size, (d) light weight, (e) reduced prime power requirements; and (4) low loss, high speed, high isolation photonic switching. Frequencies of interest range from 2.0 Mhz to 130 Ghz with emphasis at 44 Ghz, 60 Ghz, and 94 Ghz. Photonic based RF signal distribution is designed to replace metallic based low power RF signal distribution including RF antenna interconnects. Implementation of this technology can provide light weight, low loss, interference resistant - EMI (Electromagnetic Interferene), EMP (Electromagnetic Pulse), and SGEMP (Surface Generated EMP) - RF (and data) signal distribution. Devices of special concern are both broadband and narrow band high frequency, low voltage modulators with high dynamic range; high efficiency, high frequency, high dynamic range optical detectors with high power handling capability; and low loss, high speed, all optical switches. These device technologies must be capable of operation in both low and high altitude orbits in polar and in equatorial planes.

PHASE I: Provide a report and an initial laboratory technology demonstration of the proposed approach describing one of the devices addressed above.

PHASE II:Fabricate and demonstrate a device or demonstrates the technical goals of the program.

PHASE III DUAL USE APPLICATION: Reduced weight and interference for more maneuvering fuel and longer lifetime of commercial and military satellites. Applications areas include airborne platforms in the military and civilian usage along with potential applications to the cellular and personal radio communications sites.

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1. W Ng, A Narayanan, R. R. Hayes, D. Persechini, D. Yap, "High Efficiency Waveguide Coupled ?= 1.3 μm InXInXGa1-XAS/GaAs MSM Detector Exhibiting Large Extinction Ratios at L and X Band," IEEE Photonic Letters, vol. 5. pp. 514 - 517, May 1993.
2. W. B. Bridges, L. J. Burrows, U. V. Cummings, R. E. Johnson, F. T. Sheehy, "60 and 94 Ghz Coupled Electro-Optic Modulators." RL-TR-96-188 DTIC ADA318136. [NTIS: 5285 Port Royal Rd., Springfield, VA 22161]

KEYWORDS: Space, Lasers, Command, Control, Photonics, Communicatons, Electro-Optics, Photodetectors, Antenna Remoting, Optical Switching, RF Signal Distribution

AF99-242 TITLE: Reconfigurable Aperture For Sensing And Communication

TECHNOLOGY AREA: Sensors

OBJECTIVE: Demonstrate the feasibility of automated aperture reconfiguration to support multiple signal collection and transmission requirements.

DESCRIPTION: Electronic signal generation and processing are well established for a wide variety of military radar and radio equipment, covering wide sections of the electromagnetic spectrum. A significant difficulty for signal transmission and reception, however, is transitioning free-space signals of different wavelengths into and out of the electronics. Typically, a different antenna is needed for each different section of the electromagnetic spectrum (VHF, UHF, EHF, Microwave, Optical) to efficiently capture or broadcast signals. This leads to multiple antennas for satellites, command posts, mobile units, and weapon platforms to take advantage of multi-band sensing and communications. On aircraft and unmanned air vehicles, the numerous antennas increase drag and radar returns; both of which detract from mission performance. Proposed research would establish the feasibility of an antenna or aperture whose receiving/transmitting elements can be changed in near-real time to match a variety of operating wavelengths. Payoffs from the technology would include: lower RCS (radar cross-section) military aircraft, vehicles, and command posts; greater wavelength diversity to enhance target detection, increase data transmission, resist jamming/interference, and respond to hostile emanations; reduced logistics base for sensor, communication, intelligence, and avionics apertures.

PHASE I: Design a concept for reconfigurable antennas/apertures, and simulate key aspects of their multifunction capability.

PHASE II: Establish reconfigurable aperture parameters through laboratory breadboard experiments.

PHASE III DUAL USE APPLICATON: Large potential markets in security, industrial process control, medical diagnosis, exploration, and wireless communication.

REFERENCE: P.T. Ho, "Physically Adaptive Antennas," Technical Report RL-TR-95-150, Rome Laboratory, Griffiss AFB NY 13441, 1995. [(ADA 300 070) NTIS, 5285 Port Royal Road, Springfield, VA 22161]

KEYWORDS: Antennas, Conformal, Programmable, Semiconductor, Reconfigurable, Radio Frequency, Wavelength Agility, Electromagnetic Aperatures

AF99-243 Title: Enhancements To Near-field Antenna Measurements

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop elements and techniques to enhance the performance of near-field antenna measurement systems.

DESCRIPTION: The measurement of satellite antenna patterns, especially after the antennas have been integrated with the satellite, is costly and time consuming. In recent years, near-field antenna measurement systems have been developed which significantly reduce costs by scanning a probe element across the antenna aperture to measure the pattern in the near-field. Both transmit and receive antennas can be tested using near-field techniques with, respectively, either a receive or transmit probe. Near-field measurements reduce the size of antenna test ranges and chambers and shorten the test time, thus, reducing costs. In spite of the early success of near-field techniques, performance is well below theoretical limits. Innovative research can be expected to improve the performance over existing near-field systems by as much as a factor of 20. Three specific high payoff areas are: 1) improvements in the gain and phase stability of flexible cable carrying the microwave signals to/from the probe, 2) improvements in the receiver sensitivity and settling time so that the rate at which measurements are taken may be increased by an order of magnitude or more and 3) improved data acquisition and processing techniques and algorithms which will speed the evaluation and display of the

antenna characteristics.

PHASE I: 1) Perform analyses and trade-offs, concerning one or more of the high payoff areas, to determine the payoff that may be attained with the proposed techniques. 2) Develop preliminary designs and perform simulations to evaluate performance of elements selected to enhance near-field measurement systems. 3) Document results and detail a plan for prototype development/demonstration in Phase II.

PHASE II:1) Develop a working prototype the Phase I element(s) selected to enhance the performance of the near-field measurements, 2) Perform (mutually agreed) tests on the element(s) to quantify the performance improvement(s), 3) Integrate the selected element(s) with an existing near-field antenna measuring sytem and demonstrte the enhanced performance.

PHASE III DUAL USE APPLICATIONS: Improved satellite antenna measurement performance, clearly, will save costs for both military and civilian satellite systems. For military satellite systems, especially those with nulling antennas, large cost savings in the evaluation of antenna performance can be expected. Civilian systems, especially the new low orbit systems with as many as 200 satellites, each with multiple or multi-beam antennas, also will, clearly, benefit from improvements in the speed and accuracy of antenna pattern measurements.

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1. Yaghjian, A. D., An Overview of Near-Field Antenna Measurements, IEEE Trans., Antennas and Propagation, Vol. AP-34, Jan. 1986.

2. Kearns, D. M., Plane-wave Scattering-matrix theory of Antennas and Antenna-Antenna Interactions, NBS Monograph 162, U.S. Government Printing Office, Washington, D. C., June 1981.

3. Johnson, R.C., et al, Compact Range Techniques and Measurements, IEEE Trans., Antennas and Propagation, Vol. AP- 17, Sept. 1969.

KEYWORDS: Phase Stability, Data Acquisition, Receiver Stability, Near-Field Testing, Antenna Measurements, Recriver Sensitivity, Satellite Communications

AF99-244 TITLE: Omnidirectional Hemispherical Phased Array Antenna

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop cost-effective large hemispherical conformal array antenna concepts with methods of analysis and synthesis of arrays for simultaneous multibeam satellite-ground link operations.

DESCRIPTION: Satellites are linked to an earth station by transmitting and receiving a microwave beam through antennas which can be phased arrays. The requirement for a horizon-to-horizon, full hemispherical coverage of this antenna could be implemented with a large (several meters), single hemispherical conformal phased array antenna. It will provide multiple links to simultaneously support several contact operations ranging from low altitude to geostationary satellites at different directions. This would have the advantages over the conventional multiface planar phased array antenna in improved performance, less number of elements required, wide angle beam steering, efficient scheduling, and resource management. Current applications of this type of conformal array antenna are mostly small cylindrical or dome antennas. The beam is commutated around the arrays by means of a switching network which may become very complex for large antenna applications. Methods of analysis and synthesis of conformal arrays have not been developed to the same extent as the planar array antennas. Recent advancement in active antenna element and digital beam-forming technologies offers opportunities of investigating the possibility of developing cost effective large hemispherical array antennas to provide adaptive multibeam, horizon-to-horizon coverage, and multiple frequency bands for satellite control network operations. It may provide improved capabilities and reduce the overall satellite operations cost. The objective of this research is to develop low-cost hemispherical conformal phased array antenna concepts for horizon-to-horizon, simultaneous coverage of multiple satellites. Methods of analysis and synthesis of hemispherical conformal arrays shall also be formulated. Alternative concepts will be assessed in terms of their effectiveness, feasibility, and practicability.

PHASE I: Phase I activity shall include: (1) identification of general antenna requirements for supporting satellite network operations, (2) development of at least two candidate low-cost hemispherical conformal array antenna concepts supported by analysis and synthesis, (3) assessment of each candidate concept in terms of technical feasibility, application utility, operational adaptability, and economical viability, (4) identification of new technical issues relating to the practicality of specific candidate concepts, and (5) documentation of detailed conceptual designs and assessment results.

PHASE II:The Phase II activity shall include: (1) conduct of trade-off evaluation of the candidate conceptual designs to synthesize a single optimal conceptual design including multibeam control and scheduling, (2) construction of computer simulation and/or breadboard demonstration of selected antenna characteristics to support design analysis, identify key design parameters, and verify the projected capability, (3) using AF Satellite Control Network (AFSCN) as an illustrative example to develop a concept of operation employing the designed hemispherical array antenna, and evaluate the antenna's impact on the overall AFSCN performance,

(4) rough estimation of the life cycle cost of the selected antenna concept within the context of APSCN application, and (5) documentation of all technical results and lessons learned from the Phase II activities and additional technology needs.

PHASE III DUAL USE APPLICATON: The antenna concept developed in this research will be applicable to both commercial and military satellite control networks. A low-cost array antenna is capable of improving commercial satellite control network performance and reducing operational cost, especially for the ones with large constellations such as IRIDIUM and Telsdesic.

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2. Samejima, S., "Phased Array Antenna Systems for Commercial Applications in Japan," 1966 IEEE International Symposium on Phased Array Systems and Technology, pp. 237-242, October 1996.
3. Kiuchi, E., "Tactical Cylindrical Active Phased Array Radar," 1966 IEEE International Symposium on Phased Array Systems and Technology, pp. 222-225, October 1996.
4. Kanno, M., Hasimura, T. and Katada, T., "Digital Beam Forming for Conformal Active Array Antenna," 1966 IEEE International Symposium on Phased Array Systems and Technology, pp. 37-40, October 1996.
5. Larson, W. J. and Wertz, J. R., "Space Mission Analysis and Design," 2nd Ed., Microcosm, Inc. and Kluwer Academic Publishers, 1993.

KEYWORDS: Digital Beam-Forming, Active Antenna Element, Satellite Control Network, Large Phased Array Antenna, Hemispherical Conformal Array, Horizon-To-Horizon Hemispherical Coverage, Multiple Simultaneous Satellite--Ground Links

AF99-245 TITLE: Smart-pixel Turbulence Aberration Correction

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop a smart-pixel device to compensate for high-speed optical aberrations.

DESCRIPTION: Satellite and aircraft imaging sensors must locate, identify, and track distant objects in the presence of rapidly changing optical aberrations, such as those caused by severe atmospheric or aircraft boundary-layer turbulence. These aberrations can change on the time scale of microseconds. Adaptive optics systems cannot respond fast enough to correct such aberrations, especially in high-resolution, large field-of-view systems designed for satellites or high-altitude surveillance. A smart-pixel device can, in principle, respond much faster, provided any processing can be done in parallel. For example, light from a guide star can be reflected from a torsion mirror array then onto a Hartmann angle sensing array. The Hartmann sensor output can be used to control the torsion mirrors, creating a feedback loop that automatically flattens the wavefront at a speed limited only by the response time of the torsion mirrors. Other alternatives would be to include smart processing circuitry in each pixel to convert the Hartmann angle information into a signal to be applied to a spatial light modulator.

PHASE I: Construct a small proof-of-concept array to correct optical aberrations in at least one dimension.

PHASE II:Fabricate a 64x64 array that corrects two-dimensional optical aberrations with a response time of at least 10 microseconds. Design must be scalable up to array sizes of 256x256 without exceeding the response time limit.

PHASE III DUAL-USE APPLICATION: Commercial satellite imaging systems and ground-based telescope systems would benefit from such a device.

REFERENCE: Motamedi, M. E., et.al. "Micro-opto-electro-mechanical devices and on-chip processing," Optical Engineering 36, May 1997, pp. 1282-1297

KEYWORDS: Turbulence, Smart-pixel, Adaptive-optics, Aberration correction

AF99-246 TITLE: Unmanned Aerial Vehicle Antennas

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop concepts for structurally integrated lightweight airborne phased array antennas for Unmanned Aerial Vehicle (UAV) applications.

DESCRIPTION: Structurally integrated phased array antennas will have an important role on present and future UAV's. Arrays with wide angle multibeam agility will be used for communications in the HF to K band frequency range, for passive bistatic radar

functions at S-band, for active radar functions in L-band to X-band and foliage penetration from L-band to VHF. Multifunctional and multifrequency fully populated phased arrays based on tile architectures are possible candidate solutions. Low cost, lightweight and structurally integrateable antenna concepts are required to ultimately achieve acceptable life-cycle costs for UAV's. Concepts developed under this SBIR have the potential to greatly promote a quckly growing multifaceted market.

PHASE I: 1) Perform antenna concept analyses and trade-offs, for one or more phased array applications. 2) Develop preliminary antenna performance simulations to evaluate beam and frequency coverage, multifunctionality and vehicle integration. 3) Document results and detail a plan for proof-of-concept development/demonstration in Phase II.

PHASE II: 1) Produce a comprehensive structurally integrated multifunction airborne phased array simulation to validate plausible antenna architectures. 2) Identify key sub-system antenna performance requirements. 3) In conjunction with AFRL Sensors Directorate, select crucial phased array components and produce a proof-of-concept prototypes.

PHASE III DUAL USE APPLICATIONS: Improved structurally integrated multifunction airborne phased array will bring new communication and radar functionality for both military and civilian airborne systems. For military airborne radar and communication systems a large savings in the life cycle cost for surveillance assets is expected. Civilian airborne communication systems, especially large passenger aircraft with increased demand for high communication data rates, will benefit by the lower cost of mass producible structurally integrated antennas.

REFERENCE: Proceedings of the Antenna Applications Symposium, 1995, 1996, and 1997, Allerton Park, IL.

KEYWORDS: Antennas, Pphased Array, Space Fed Lens, Constrained Feed, Structural Antennas

AF99-247 TITLE: Laser Radar For Long-range Ranging And Non-cooperative Identification

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop advanced, laser radar techniques and components for long-range, Space/Air non-cooperative identification, ranging, and tracking.

DESCRIPTION: With the advent of multi-national conflicts involving a variety of friends, foes, and non-combatants, long-range non-cooperative identification (NCID) has become an extremely important aspect of battle management. Research has shown that a variety of ladar (laser radar) modes have the potential to contribute to the long-range NCID solution from both airborne and space platforms. The limited aperture sizes dictated by platform real estate limit the useful range of spatially-resolved imaging and drive the solution to multi-function shared aperture implementations. Non-imaging, high temporal resolution ladar (1D ladar) or range-Doppler ladar (velocity or vibration sensing) promises to provide a viable solution to the long-range NCID requirement utilizing designator-class laser systems. The nature of the 1D-ladar signature is relatively range independent and should have utility well beyond the aperture limited imaging limit. Acceptable research would examine novel extended range ladar concepts and techniques. Proposed transceiver concepts should focus on providing solid-state, eye-safe NCID implementations that maximize multi-function, shared-aperture operation including at least precision range (< 30 cm resolution) and designation (> 100 mJ/pulse) capabilities. The program may examine, but is not limited to 1D pulse shape and pulse modulation techniques; extended information extraction from 1D returns; range-Doppler techniques; novel transmitter design approaches for both 1D and range Doppler; automatic target recognition; and other promising long-range optical ID concepts. All concepts should develop transmitter/receiver specifications and preliminary designs, examine wavelength optimization based on analysis atmospheric effects, and develop performance predictions based on the proposed 1D concepts and transceiver specifications.

PHASE I: Design and assess laser transmitter and receiver architectures and critical component technologies. The approach to achieving long-range target identification will be defined. Critical issues associated with the technique including transceiver designs, feasibility demonstrations of key technologies, and atmospheric propagation from both air and space-based platforms will be investigated.

PHASE II:Fabricate and quantitatively evaluate an eye-safe ladar for long-range identification technique demonstration. Critical issues associated with the technique and the associated transceiver would be addressed and fabrication approaches would be demonstrated.

PHASE III DUAL USE APPLICATION: High-resolution laser radars at eye-safe wavelengths would greatly increase the potential applications of laser radar systems. Potential commercial applications include surveying, time-of-flight imaging for medical diagnostics, ocean research, and space object imaging applications. Imaging in factories for process control, imaging for nondestructive testing, and imaging for surveillance and security are also examples where this technology can be applied.

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1. F. K. Knight, D. I. Klick, D. P. Tyan-Howard, J. R. Theriault, and B. K. Tussey, "Two dimensional tomographs using range measurements," Proc. SPIE Vol. 999 (1988).
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3. J. A. Overbeck, M. S. Salisbury, M. B. Mark, and E. A. Watson, "Required energy for a laser radar system incorporating a fiber amplifier or an avalanche photodiode," Appl. Opt. 34(33), 7724-7730 (1995).

KEYWORDS: Ladar, Laser, Detection, Laser Radar, Laser Ranging, Laser Doppler, Non-Cooperate Identification

AF99-248 Title: Real Time Non-mechanical Microscanning Techniques

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop new or improved techniques, algorithms or algorithm coding to accomplish real-time non-mechanical microscanning (microdithering) for infrared sensors.

DESCRIPTION: Military and commercial imaging infrared sensors are transitioning from one-dimensional linear arrays to two-dimensional staring arrays. The resolution of staring infrared imaging sensors is limited due to the optics as well as by both the physical dimensions of the detector elements in the focal plane array and the detector pitch. These sensors tend to be inherently under sampled, resulting in aliased imagery. Resolution improvement can be accomplished by reducing the effective detector pitch and increasing the sampling frequency through a technique referred to as dithering, or microscanning. Additional enhancement is possible through deconvolution of the detector and optics blurring. Microscanning involves processing a sequence of frames where the field-of-view of each frame is displaced slightly (typically subpixel) from the other frames to create a high-resolution image. Microscan motion can be induced in a controlled or uncontrolled manner using a mechanical dither mirror and/or platform motion. Common image processing elements of current algorithms include subpixel registration, image interlacing, high-resolution pixel estimation, and deconvolution. Recursive algorithms employing maximum-likelihood or maximum a posteriori estimation techniques have proven to be very effective. However, they are computationally intensive and real-time implementation on multi-processor systems is not currently possible. Faster algorithms which use gradient-based registration and simplified deconvolution hold promise for real-time implementation, but for image sizes approaching 1024 X 1024 pixels, this becomes extremely challenging. Complex nonglobal image motion and affine transformation between image frames further complicates image processing. Real-time microscanning requires improvements of 30-100 times versus the techniques used to date. Such performance improvements could be realized with better algorithms, more efficient coding tools and techniques, or specialized processing hardware.

PHASE I: Define and evaluate approaches, based on non-mechanical microscanning algorithms, coding tools, and/or techniques, to obtain real-time microscanning in infrared imaging sensors.

PHASE II: Develop, demonstrate and deliver selected concept defined during Phase I.

PHASE III DUAL USE APPLICATIONS: The ability to perform real-time microscanning has wide application in remote sensing, machine vision, and surveillance. Other general-purpose image processing also requires more efficient implementation and could benefit from better coding tools and techniques.

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KEYWORDS: Dither, Subpixel, Infrared, Microscan, Imaging Sensors, Image Processing

AF99-249 TITLE: Multispectral Infrared Phenomenology For Combined Threat Warning And Reconnaissance Sensors

TECHNOLOGY AREA: Sensors

OBJECTIVE: Determine the feasibility of a single multispectral infrared sensor capable of missile threat warning and ground target detection.

DESCRIPTION: Proposed solutions for missile threat warning and subpixel detection of ground-based targets indicate differences of band / subband selection and angular field of view (FOV) / field of regard (FOR). A common sensor or even common modules, if achievable, would have substantial payoff for the military and commercial markets for ground, air, and space applications. For both functions, multicolor IR has been shown to provide excellent clutter rejection for specific band combinations. The missile threat warning sensor must detect the presence of a threat in a cluttered environment, on short time lines, with a minimum number of false alarms. For this function, the desire to detect missile plumes with minimum background contribution has driven multicolor designs to the Mid-IR spectrum. For multispectral or hyperspectral sensors in surveillance or reconnaissance applications, target detectability is enhanced by exploiting spectral features which have large separation from the highly correlated background for certain spectral combinations. For subpixel target detection, spectral mixing of target and background features must be accounted for. Presently, the optimum bands (and number of bands) for this function is not well understood and is often generalized from specific field scenarios. Initial indications are that LWIR subbands provide more robust discrimination. Increased demand for compact, affordable IR sensors makes the combination of these two, seemingly incompatible functions, highly desirable. Since cost is a major concern, a single sensor either in just the midwave, or one capable of both midwave and long wave subbands would be highly desirable, even if different front end optics had to be used for each application, due to FOR issues.

PHASE I: Investigate spectral properties to enable detection of tactical missiles, theater missiles, and ground targets, to include deep-hide, camouflaged, and concealed targets. Background clutter effects for various terrain and climate scenarios must be considered. For missile threat warning, low false alarm rates over a WFOR must be a constraint. For subpixel target detection, spectral mixing effects at long range must be considered. Phase I will conclude with identification of candidate bands / subbands and a definition of a preliminary sensor design, or sensor module designs.

PHASE II:Validate spectral band optimization through a series of simulations over a broad range of targets and backgrounds. Fabricate a breadboard sensor with sufficient portability to conduct a variety of tower and field measurements. Different optical front ends may be used for each application, if required.

PHASE III DUAL USE APPLICATION: Numerous non-military markets which exploit thermal measurements benefit from this development. The common-mode sensor has concurrent applicability for intrusion detection, collision warning, oil and mineral exploitation, and environmental monitoring.

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KEYWORDS: Imaging, Thermal, Subpixel, Infrared, Detection, Hyperspectral, Multispectral, Classification, Spectral Mixing, Missile Warning

AF99-250 TITLE: Modular, Multi-discriminanat Electro-optical Sensors-munitions To Satellites

TECHNOLOGY AREA: Sensors

OBJECTIVE: Design a multi-discriminant electro-optical (EO) sensor architecture which can be scaled from a core sensor module to an n-module system and can be hosted on platforms ranging from munitions to satellites.

DESCRIPTION: The capability exists today to develop EO sensors which can sample and process a variety of target discriminants such as 3-D spatial, spectral, thermal, vibration, polarization, etc. Increasing the number of sensed discriminants often increases confidence for target detection, tracking, identification, engagement, and damage assessment. The number of discriminants to be sensed must be traded between target difficulty and host platform volume/cost constraints. Developing federated sensors suitable for the broad range of target tasks and host platforms is financially prohibitive. Recently there has been increased emphasis in developing multi-function EO sensors; for example, sensors which can sample 3-D spatial features via laser radar as well as additional

discriminants, such as micro-Doppler for vibration sensing. The need exists for a sensor architecture which can start with a core sensor module and be scaled up, in a modular sense, as the need for additional discriminants is mandated. The core sensor would be designed for a low-cost smart munition, hence, could presumably be a short-range laser radar sensor. A more basic core sensor might be designed for the automotive industry, thus, motivating a very high-volume, low-cost core. As the host changes to manned and unmanned aircraft or space platforms, and the mission mandates additional discriminants, the core sensor would be scaled by additional discriminant modules. Power scaling of a laser source should also be considered. Analogous to the sensor modules, this effort will identify core processing requirements, scalable in a modular sense to accommodate increased discriminant processing.

PHASE I: Identify a core sensor and processing architecture suitable for a low-cost smart munition; e.g., laser radar seeker. A more basic module for an automobile proximity and collision warning sensor would be desirable from a cost standpoint, which in turn would be scaled to a munition package. The core design should include an "expansion" capability for adding additional discriminants. Candidates to be considered may be active, passive, or a combination and will be collaboratively finalized by the government and small business principal investigators in the early part of Phase I. The intent of Phase I is to determine if modular EO sensors can be realizable and scalable for a large number of missions and platforms; hence, a phenomenological prioritization of discriminants is not required for this topic.

PHASE II: From a core sensor and a discrete set of additional discriminant modules, fabricate a breadboard sensor with sufficient portability to perform a variety of tower and field measurements.

PHASE III DUAL USE APPLICATION: A core laser radar module in a low-cost package has applicability for an automobile collision warning system as well as a host of commercial terrain mapping and natural resource management systems. A modular, scalable package could be employed in a variety of airborne and space vehicles for weather profiling, crop reporting, etc.

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KEYWORDS: Ladar, Sensors, Modular, Munitions, Laser Radar, Multifunction, Remote Sensing, Electrol-Optical, Multi-Discriminant

AF99-251 TITLE: Global Positioning System (Gps) Receiver Antenna For Spinning Satellite

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop a spaceborne antenna for use onboard a spinning satellite to track all-in-view GPS satellites.

DESCRIPTION: There is a global need for satellite position determination (during launch and in orbit) for both government and commercial satellites. The Air Force has specific requirements for satellite position determination. The position of a satellite during launch is currently tracked by ground monitor stations using an S-Band signal. Sometimes, the reliability of the tracking data is in question. The launch and on orbit position of a satellite could also be determined by a GPS receiver onboard the satellite that can continuously track all-in-view GPS Satellites. The Position information could then be down linked to the ground monitor stations for position determination. During launch and in orbit, the satellite could be spinning at up to 60 revolutions per minute and its attitude also changing: therefore, the type of receiver antenna and the location of the antenna onboard the satellite should be examined to ensure that it can track all-in-view GPS satellites continuously. At a minimum, the following issues should be addressed: 1. Antenna location, 2. Antenna pattern (a broad beam pattern to meet the beamwidth and to give a gain level above a specified requirement for the field-of-view), 3. Antenna gain (the gain can not be constant but will roll off. This gain roll off should be gradual and smooth with a ripple not to exceed a certain level. This gain ripple will be caused by factors such as multipath, blockage, and the switching between antenna elements in the array), 4. Antenna beam efficiency, 5. Antenna polarization purity, 6. Antenna tuning (The antenna will be tuned to center frequency and should not be allowed to drift or detune outside of a specified range), 7. Voltage Standing Wave Ratio, 8. Insertion loss and isolation between elements, and 9. Surviving environmental factors such as extreme heat, thermal cycling and vibration.

PHASE I: Effort will include: 1. Develop a candidate antenna design to meet the intended requirement, 2. Government input will provide target values for the above requirements/variables, 3. Provide design documentation that provides proof of design concept, and 4. Demonstration of (mutually agreed) key technology elements of the chosen antenna design.

PHASE II: 1. Complete detailed design of the candidate antenna, 2. Build and demonstrate a prototype of the final antenna design in concert with an appropriate GPS Receiver.

PHASE III DUAL USE APPLICATION: This antenna technology can be sued for GPS tracking of commercial satellites during launch and at all orbital altitudes.

REFERENCE: Global Positioning System: Theory and Applications Volume 1, Edited by Bradford W. Parkinson, James J. Spiker Jr., Published by: The American Institute of Astronautics and Aeronautics (AIAA)

KEYWORDS: S-Band Signal, Satellite Antenna, Orbit Determination, Position Determination, Space-Based GPS Antenna, Global Positioning System

AF99-253 TITLE: Global Positioning System Advanced Controlled Reception Pattern Antenna And Electronics

TECHNOLOGY AREA: Sensors

OBJECTIVE: Design, and develop a Controlled Reception Pattern Antenna that reduces interference and multi-path by adaptive cancellation.

DESCRIPTION: The cellular phone industry has spent millions of dollars to reduce the effects of multi-path and interference in very highly cluttered environments. The cellular phone industry has millions of users that require low cost lightweight solutions. These low cost lightweight solutions could also benefit the Global Positioning System in the reduction of jamming, multi-path or unintentional interference. The current Controlled reception pattern antenna uses a seven-element array. The cost of the current array and electronics is over $25,000. The goal of this program is to reduce the system cost (antenna, electronics and software) to less than $10,000. The system is required to null six broadband interference sources Additional areas of interest are true time delay beam and null steering for a low cost implementation of a Controlled Reception Pattern Antenna.

PHASE I: 1.) Investigate a candidate antenna configuration, 2.) Determine the optimum antenna pattern given the satellite orbits and receiver considerations and the location of potential interference. Calculate improved antenna performance and antenna gain patterns.

PHASE II: Fabricate a candidate advanced controlled Reception Pattern Antenna and test in the presence of multiple noise sources in an anechoic chamber or an outdoor test range.

PHASE III DUAL USE APPLICATION: GPS receivers used in urban environments for survey equipment and vehicle location tracking often have problems with interference from ground based sources. These commercial users could benefit from a Controlled Reception Pattern Antenna with low cost interference suppression.

REFERENCE:
1. Guttrich, Sievers and Tomljanovich, "Wide Area Surveillance Concepts Based on Geosynchronous Illumination and Bistatic Unmanned Airborne Vehicles or Satellite Reception." The MITRE Corp., 1997.
2. "Space-Time Adaptive Processing for Advanced Airborne Surveillance (AAS) Bistatic Radar," Sanyal and Melvin, MITRE & USAF Rome lab June 1997
3. 1997 IEEE Aerospace Conference, Aspen, CO, Feb. 1-8, 1997, Proceedings. Vol. 2 (A97-44051 12-99), Piscataway, NJ, Institute of Electrical and Electronics Engineers, Inc., 1997, p. 171-180.

KEYWORDS: Antenna, Low Cost, Anti-Jam, Fixed Antenna Pattern, Interference Reduction, Global Positioning System

AF99-255 TITLE: Real-time Multi-spectral Synthetic Battlespace

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop real-time multi-spectral synthetic battlespace environment simulations for developing/transitioning advanced airborne/space sensor technologies.

DESCRIPTION: Man/hardware-in-the-loop laboratory simulation is the most cost-effective evaluation methodology for maturing advanced sensor technologies because the battlefield can be brought to the laboratory through multispectral synthetic battlespace simulation. Multispectral synthetic battlespace simulation provides precise control of the test conditions which enables the advanced sensor technologies to be subjected to multiple realistic combat situations making it possible to identify/resolve technology issues before ever flying or fielding the capability. It is a critical step that significantly reduces the time, risk and especially cost associated with transitioning advanced sensor technologies. These advanced sensor technologies provide a multispectral view that is integrated through information processing for a highly accurate assessment of the battlefield situation for the warfighter. Current laboratory

simulation technologies cannot generate the real-time high fidelity multispectral environment required for conducting realistic advanced technology demonstrations.

PHASE I: Identify innovative real-time simulation technologies that enable multi-spectral synthetic battlespace environment generation for the development, demonstration, and transition of advanced sensor technologies for airborne/space applications. The Phase I research will identify the critical simulation technology challenges and define the Phase II approach for developing/demonstrating the critical simulation technology required for real-time multi-spectral synthetic battlespace environment generation in the Sensors Directorate Integrated Demonstrations and Applications Laboratory (IDAL). Phase I risk reduction experiments will be conducted to demonstrate the feasibility of the proposed Phase II approach.

PHASE II: Implement and demonstrate the critical real-time multi-spectral synthetic battlespace environment generation simulation technology in the Sensors Directorate Integrated Demonstrations and Applications Laboratory (IDAL).

PHASE III DUAL USE APPLICATION: Multi-spectral synthetic battlespace environment generation simulation technology is a dual-use technology that has extensive commercial applications for markets such as the security protection and airline industries. This simulation technology can be utilized to develop information processes that fuse data from multi-spectral sensors to provide highly accurate real-time situation assessments for the commercial security protection market. This simulation technology can also be utilized to develop and evaluate low visibility aircraft landing system concepts involving multi-spectral imaging systems. This simulation technology will reduce development costs and accelerate product movement to the market place.

REFERENCE: McQuay, W. K., "J-MASS and Concurrent Simulation in the Laboratory Environment," p585-7. Proceedings of IEEE NAECON '96, National Aerospace and Electronics Conference, 1996. A96-37576.

KEYWORDS: Sensors, Real-Time, Synthetic, Simulation, Battlespace, Multi-Spectral

AF99-256 TITLE: "System Of Systems" Network Centric Sensors Demonstration Testbed

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop "system of systems" technology demonstration/application testbed for evolving advanced network centric concepts.

DESCRIPTION: Joint Vision 2010 (JV2010) utilizes operational concepts of Dominant Maneuver, Precision Engagement, Focused Logistics and Full Dimensional Protection with Information Superiority for joint warfighting. One of the key challenges in this vision is understanding how advanced sensors combined with Information Superiority can be exploited for a "system of systems" approach that provides "networks" of sensors, command and control, and shooters to enable "Network-Centric Warfare." This type of capability will be applied to the next generation aircraft such as the Joint Strike Fighter (JSF) to provide the ability to delay detection by our adversaries by reducing its radar, infrared, and emissions signature through a SoS approach that retains a high degree of accuracy, lethality, survivability and mission flexibility. The Sensors Directorate Integrated Demonstrations and Applications Laboratory (IDAL) is evolving advanced sensor and information processing technologies through collaborative engineering environments where the IDAL sensor testbeds are linked to other government/industry research facilities to form a collaborative advanced technology demonstration capability.

PHASE I: Identify innovative real-time simulation technologies required for an IDAL "system of systems" technology demonstration/application testbed for evolving advanced network centric concepts involving both airborne and space sensor assets. The Phase I research will identify the critical simulation technology challenges and define the Phase II approach for developing/demonstrating the critical simulation technology required for a "system of systems" network centric sensors demonstration testbed in the Sensors Directorate Integrated Demonstrations and Applications Laboratory (IDAL). Phase I risk reduction experiments will be conducted to demonstrate the feasibility of the proposed Phase II approach.

PHASE II: Implement and demonstrate the critical "system of systems" network centric sensors demonstration testbed simulation technology in the Sensors Directorate Integrated Demonstrations and Applications Laboratory (IDAL).

PHASE III DUAL USE APPLICATION: Network centric simulation technology is a dual-use technology that has extensive commercial applications for markets such as the computer and communication industries. This simulation technology can be utilized to develop parallel information processes for computer implementation that enhance current commercial computers. This simulation technology can also be utilized to develop communications networks that can address the growing marketplace need for enhanced information processing.

REFERENCE:
1. McQuay, W. K., "J-MASS and Concurrent Simulation in the Laboratory Environment," p585-7. Proceedings of IEEE NAECON '96, National Aerospace and Electronics Conference, 1996. A96-37576.

2. INFORMATION PAPER: Obervations of the Emergence of Network-Centric Warfare. http://www.dtic.mil/jcs/j6/education/warfare.html.

KEYWORDS: Sensors, Testbed, Simulation, Demonstration, Network Centric, System of Systems

AF99-257 TITLE: Air Target Combat Identification Technologies

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop new and innovative techniques for Combat Identification of air targets.

DESCRIPTION: The Air Force is actively pursuing Combat Identification (CID) capabilities for use in modern fighter aircraft and from space-based platforms. Current capabilities are not robust and require significant pilot attention for positive CID. The Vincennes Disaster, Desert Storm, and Operation Deny Flight have demonstrated the critical need to positively identify air targets. The destruction of hostile air targets while preserving non-combatant, neutral, and friendly aircraft remains a top priority. Identification must positively declare aircraft type to enable high-confidence engagement decisions. Class level declarations, whether cooperative or non-cooperative, may be considered viable components of a type level CID system of systems. One primary sensor for CID is radar with emphases on airborne tactical radar systems and space-based systems. These systems allow the active or passive collection of multi-mode electromagnetic data which might prove suitable for CID exploitation. CID of air targets is currently performed by signature pattern matching or by performing specialized processing to the radar signature. Other target information in the returned radar signal that is ignored or lost due to advanced processing may provide additional features and characteristics improving overall CID. Since there are no predefined sets of exploitable electromagnetic features that uniquely describe targets under all conditions, processes that can yield a robust, high-confidence feature/capability for discrimination should be examined under this research topic. For example, such processes may include radar signature information with complex vibratory or target feature inter-relationships.

PHASE I: Investigate and identify features, characteristics, and innovative informational relationships for target identification. Based upon these results, develop concepts for signature exploitation, CID algorithm designs, and performance evaluation.

PHASE II:Develop and demonstrate the signature exploitation CID algorithm.

PHASE III DUAL USE APPLICATION: Advances in target identification has applications in drug interdiction, air traffic control, industrial inspection, and manufacturing automation.

REFERENCE: Cranos, Roger, "Combat Identification in the Future: Maintaining a Balance," presented at the Society of Photo-Optical Instrumentation Engineers (SPIE) 11th Annual International Symposium on Aerospace/Defense Sensing, Simulation and Controls, 20-25 April 1997.

KEYWORDS: Radar, Lasers, Infrared, Signal Processing, Target Recognition, Combat Identification

AF99-258 TITLE: Surface Target Combat Identification Technologies

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop new and innovative techniques for Combat Identification of surface targets.

DESCRIPTION: The Air Force is actively pursuing Combat Identification (CID) capabilities for use in modern fighter aircraft and from space-based platforms. Current capabilities are not robust and require significant pilot attention for positive CID. Desert Storm demonstrated the critical need to positively identify surface targets. The destruction of hostile surface targets while preserving non-combatant, neutral, and friendly vehicles remains a top priority. Identification must positively declare vehicle type to enable high-confidence engagement decisions. Class level declarations, whether cooperative or non-cooperative, may be considered viable components of a type level CID system of systems.

One primary sensor for CID is radar with emphases on airborne tactical radar systems and space-based systems. These systems allow the active or passive collection of multi-mode electromagnetic data which might prove suitable for CID exploitation. Programs exist that provide algorithms and data for stationary ground target location and ID (i.e.; Moving and Stationary Target Acquisition and Recognition (MSTAR) program) and that provide high range resolution algorithms and techniques for detection of ground moving targets (i.e.; System High Range Resolution A/G Recognition (SHARP) and Moving Target Exploitation (MTE) technology development programs). Since there are no predefined sets of exploitable electromagnetic features that uniquely describe

targets under all conditions, processes that can yield a robust, high-confidence feature/capability for discrimination should be examined under this research topic. For example, such processes may include radar signature information with complex vibratory or target feature inter-relationships.

PHASE I: Investigate and identify features, characteristics, and innovative informational relationships for target identification. Based upon these results, develop concepts for radar signature exploitation, CID algorithm designs, and performance evaluation.

PHASE II: Develop the radar signature exploitation CID algorithm.

PHASE III DUAL-USE APPLICATION: Advances in target identification has applications in drug interdiction, vehicle/container control and tracking, industrial inspection, and manufacturing automation.

REFERENCE: Cranos, Roger, "Combat Identification in the Future: Maintaining a Balance," presented at the Society of Photo-Optical Instrumentation Engineers (SPIE) 11th Annual International Symposium on Aerospace/Defense Sensing, Simulation and Controls, 20-25 April 1997.

KEYWORDS: Radar, Lasers, Infrared, Signal Processing, Target Recognition, Combat Identification

AF99-259 TITLE: Innovative Planning Tool For Urban Electromagnetic Environment Characterization

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop techniques and tools to accurately characterize and manage electromagnetic environments in urban areas for improved performance of Air Force sensor and communication systems.

DESCRIPTION: The Air Force must acquire the capability to accurately characterize and predict urban electromagnetic environments at all potential operating frequencies used by present and future sensors and communication systems. The research of sample opearating scenarios will include the parametric characterization of urban clutter phenomenology for space-based and airborne radar systems, and the estimation of signal interference and attenuation for battlefield wireless networks. The databases of high-resolution digital terrain maps collected by the National Imagery and Mapping Agency (NIMA) and other agencies enable the construction of high-fidelity CAD models of urban areas including natural and manmade structures such as parks, buildings, roads and bridges. These CAD models can be used to perform accurately detailed, scenario-specific simulations of urban electromagnetic effects on Air Force systems.

PHASE I: (1) Develop conceptual design for an interface between the high-resolution digital map databases and a sample CAD program. (2) Using this interface design, investigate the construction of CAD models of urban areas appropriate for electromagnetic simulation. (3) Document these results and provide a detailed plan for prototype development in Phase II.

PHASE II: (1) Develop proof of concept prototype CAD software package based on work done under Phase I. (2) Identify issues pertinent to accurate modeling of electromagnetic scattering and diffraction from manmade structures. (3) Refine techniques used to predict scattering and diffraction from manmade structures and implement them.

PHASE III DUAL USE APPLICATION: The commercial potential is excellent. With exponentially increasing reliance on cellular and wireless communications for voice, data, image and video transmission, the technology base developed under this SBIR is expected to be fully exploited by established and emerging companies alike. In addition, the Federal Aviation Administration (FAA) can take advantage of this technology to characterize urban clutter for optimizing the performance of air port surveillance radars.

REFERENCES:
1. K. Sivaprasad, A. Drake and S. Rajan, "Urban Discrete Clutter Sources," Rome Air Development Center Technical Report TR-86-70.
2. R. Akturan, W. Vogel, "Path Diversity for LEO Satellite-PCS in the Urban Environment," IEEE Trans. Antenna. Propagat., Vol 45, no. 7, July 1997, pp11071116.

KEYWORDS: Cad Models, Urban Propagation, Digital Terrain Maps, Urban Terrain Clutter, Electromagnetic Scattering, Urban Electromagnetic Environments

AF99-263 TITLE: Subpixel Detection Concepts For Space-based Infrared Hyperspectral Imaging

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop innovative infrared hyperspectral imaging techniques for space-based day/night surveillance and reconnaissance applications

DESCRIPTION: Infrared targeting systems based solely on spatial and thermal detection phenomenology are fundamentally limited in performance for several important scenarios: extended ranges, wide area search, low contrast conditions, and deep hide and camouflage, concealment, & deception (CC&D) targets. Multispectral discrimination presents an opportunity for significant enhancements in target detectability by exploiting characteristic target spectral (color) features and high background spectral correlation. By extending the spectral information content in this way, the spatial resolution requirements can potentially be relaxed to detect and discriminate target materials which occupy as little as a fraction of a pixel. Results to date under the current program, Brassboard Airborne Multispectral Sensor System Specification (BAMS), have supported this potential of multispectral sensing through extensive spectral measurements and subsequent performance measurements over a range of targets, backgrounds, and environmental conditions. The BAMS program is part of a tri-service research area called the Joint Multispectral Program (JMSP). The performance goals are high probability of detection, low false alarm rates and wide area search capabilities. As part of the BAMS program, multi- and hyperspectral sensor design trades are being refined based on an expanded target/background database. These trades include sensor parameters such as: spectral bands, spectral bandwidths, noise equivalent spectral radiance, band-to-band registration, etc. Currently, the Space-Based Hyperspectral Sensor Technology Initiative was established to provide the warfighter a day/night global surveillance capability to detect and recognize targets and target materials. The initiative capitalizes on the BAMS program by expanding high-altitude airborne reconaissance hyperspectral efforts to mature the technology to the point that demonstration on a space platform is viable. The OBJECTIVE of this SBIR topic is to develop a better understanding of the phenomenology of spectral mixing within a region and to develop sub-pixel detection and classification approaches for an affordable, calibrated, optically-registered multi-band (>100 bands) thermal imaging system using available focal plane arrays. These approaches must focus on satisfying the performance requirements for high probability of detection and low false alarm rate performance for sub-pixel target detection/ classification from a sensor based on a space platform.

PHASE I: Investigate and understand effects of spectral mixing between target materials and background clutter within a region when sensed remotely by a thermal hyperspectral imaging sensor, and determine the potential performance for sub-pixel detection/classification, including fundamental limits of performance using existing thermal spectral data.

PHASE II: Develop sub-pixel detection and classification techniques for a thermal hyperspectral sensor based on performance trades and phenomenology understanding accomplished in phase I. Determine critical sensor performance specifications including selecting thermal wavebands, spatial and spectral resolution, and noise requirements based on developed techniques. Optimize the approach for a selected sensor. This phase should result in the delivery of the sub-pixel detection and classification techniques in a software package.

PHASE III DUAL USE APPLICATION: Many non military target spectral signatures are of interest in the thermal region. Dual use of a sensor employing this technique may be desired for oil and mineral exploration, agricultural assessments, and pollution and environmental monitoring.

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1. Erdman, Carey D., Robert L. Huguenin, and Lawrence A. Scarff, "Utilizing subpixel identification schemes to address emerging application areas," Proc. SPIE 3119, 196-204 (9/1997)
2. Goetz, Alexander F., Bruce Kindel and Joseph W. Boardman, "Subpixel target detection in HYDICE data from Cuprite, Nevada," Proc. SPIE 2819, 7-14 (11/1996)
3. Harsanyi, Joseph C. and Chein-I Chang, "Hyperspectral image classification and dimensionality reduction: An orthogonal subspace projection approach", IEEE Trans. Geoscience and Remote Sensing, 32(4), 779-785 (1994)
4. Huguenin, Robert L., Karaska, Mark A., and John R. Jensen Subpixel Classification of Bald Cypress and Tupelo Gum Trees in Thematic Mapper Imagery," Photogrammetric Engineering and Remote Sensing, 63(6), 717-726 (Jun 01 1997)
5. Iverson, A. Evan, "Subpixel object detection and fraction estimation in hyperspectral imagery," Proc. SPIE 3071, 61-72 (8/1997)

KEYWORDS: Imaging, Thermal, Subpixel, Infrared, Detection, Hyperspectral, Multispectral, Remote Sensing, Classification, Spectral Mixing

AF99-265 TITLE: Piezoelectric Actuators in High Strain Field

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop innovative piezoelectric actuator concepts which survive in high strain fields for aircraft vibration control.

DESCRIPTION: This SBIR topic supports the Department of Defense's Air/Space Vehicles key technology area as well as the Aging Aircraft and Access to Space Thrusts. Innovative piezoelectric actuator concepts are solicited. These actuators will ultimately be used in the suppression of vibrations in aircraft structures caused by impinging unsteady air loads. The research will develop and characterize piezoelectric actuator concepts that can withstand severe localized strain levels. The research will study reliability and maintainability (R&M) issues involved with the design and integration of the actuator system concepts. The actuators and their support equipment must be light weight, low volume, and must be designed to be integrated into an aircraft system considering environmental, electrical, and mission impacts. The employment of this concept will eliminate or reduce structural vibrations that often lead to fatigue and will improve flight vehicle life cycle costs and mission performance. A working knowledge of vibrations, unsteady aerodynamics, aeroelasticity, fatigue, controls, and aircraft subsystem packaging is required.

PHASE I: Perform design and feasibility investigations (primarily analytical) of the submitted concept considering a current operational aircraft. This research will focus on estimating the benefits attained by implementing a vibration suppression system that utilizes these actuators in terms of reduced fatigue, increased R&M as well as looking at preliminary integration issues.

PHASE II:Perform demonstration and validation test by applying concept developed in Phase I to a dynamically scaled vertical tail structure similar to a full-scale F/A-18 vertical tail.

PHASE III DUAL USE APPLICATION: Vibration suppression systems that utilize robust piezoelectric actuators have applications in a number of military and commercial environments including spacecraft, aircraft, naval vessels, and ground vehicles.

REFERENCES:
1. Lazarus, K.B., Saarmaa, E., and Agnes, G.S., "An Active Smart Material System for Buffet Load Alleviation," Proceedings from SPIE's 2nd Annual International Symposium on Smart Structures and Materials, Volume 2447, 1995, pp. 179-192.
2. Hauch, R.M., Jacobs, J.H., Dima, C., and Ravindra, K., "Reduction of Vertical Tail Buffet Response using Active Control," Journal of Aircraft, Volume 33, Number 3, May-June 1996.
3. Moore, J.W., Spangler, R.L., Lazarus, K.B., and Henderson, D.A., "Buffet Load Allevaition using Distributed Piezoelectric Actuators," Symposium on Adaptive Structures, ASME International Mechanical Engineering Congress and Exposition, Atlanta GA, November 1996.

KEYWORDS: Piezoceramics, Localized Strain, Modal Strain Energy, Vibration Suppression, Buffet Load Alleviation, Piezoelectric Actuators, Active Vibration Control

AF99-266 TITLE: High Temperature Structure Explosive Joining Development Program

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Define, develop and apply explosive joining to high temperature space vehicle structure.

DESCRIPTION: Joining of structural components on future space vehicles is a major contributor to the overall cost, weight and structural performance of the space vehicle. Explosive joining is an advanced method of joining in which controlled energy of a detonating explosive is used to create a metallurgical bond between two or more similar or dissimilar materials. Explosive joining could be used to increase the affordability of aircraft structures by eliminating costly mechanical fastening or splices in structural design and increasing the structural durability in a severe high temperature environment. Explosive joining also could replace areas of a space vehicle with bimetallic materials which are more affordable and durable than what is used in common design and manufacturing practices today. In addition, explosive joining could also be used in space vehicle structural repair. The creative use and application of explosive joining will increase the affordability and structural performance of the vehicle, while satisfying the severe high temperature structural requirements of the space vehicle.

PHASE I: Phase I would involve the analysis of a space vehicle and selection of a potential candidate structure that could be fabricated from the application of explosive joining to the specific part or built-up structure. The candidate would be selected based on known areas that need improvement, concentrating on areas of the vehicle subject to severe thermal loading. Examples could include heat exchangers, elevated temperature metallic tankage, and unprotected metallic control surfaces. Initial explosive joining trials would be conducted to address joint design properties for the necessary high temperature aerospace alloys used in the proposed space vehicle structure.

PHASE II: Phase II would involve the redesign of the space vehicle part or built-up structure to facilitate explosive joining

to decrease structural cost and weight. The candidate part redesign task would include significant coupon and subelement testing to develop the design data and structural testing to validate the proposed designed part or built-up structure. This building block approach would create the necessary design data base and joining parameters to validate the use of explosive joining in high temperature space vehicle parts and built-up structure.

PHASE III DUAL USE APPLICATIONS: This advanced method of joining offers design alternatives for future space vehicle structures as well as opportunities for weight and cost savings for future military aircraft such as the Joint Strike Fighter and for current military aircraft such as the F-15, F/A-18 and F-22. Explosive joining could impact the fabrication of commercial aircraft through cost and weight reduction, also. The use of explosive joining could be further expanded to include ship building, the chemical processing industry, the nuclear and gas pipeline industries and automobile and bus manufacturing.

REFERENCES: WL-TR-97-3033,"Explosive Joining Application Study," January 1997., WL-TR-97-3034, "Advanced Structural Joining," January,1997.

KEYWORDS: Cladding, Explosive Welding, Explosive Joining, Bimetallic Bonding, Explosive Cladding

AF99-267 TITLE: Extreme Environments Support/Space Applications

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop structural concepts (TPS, tanks, structures) and methodologies to assess hypersonic air vehicle structures manufactured with advanced materials

DESCRIPTION: There is an increased focus on the technologies necessary to develop airframe structure using advanced materials, for high speed vehicles, operating under severe thermal and acoustic loads. These loads, caused by high speed (>M 5) in the atmosphere and atmospheric reentry, are driving the design of these vehicles. Durable, lightweight thermal protection systems, hot structures, actively cooled structures and tanks that are affordable are necessary to meet expected weight goals. Many materials technologies have matured significantly since the National Aerospace Plane Program, these material advances, combined with advances in computational methods, need to be researched to achieve current system goals. Research efforts could involve the evaluation of using advanced materials, such as ceramic matrix composites and graphitic foam, or advanced processes such as E-Beam curing to develop and analyze high-speed vehicle structures. In addition, research in the methodologies necessary to develop these advanced structures could also be accomplished.

PHASE I: Develop analytical methodologies and concepts

PHASE II: Methodologies and concepts developed in Phase I will be validated by experimentation.

PHASE III DUAL USE APPLICATIONS: The development of structures using advanced materials can be transferred into the commercial market in both the aircraft and automotive industries. The development of these new structures will result in stronger, lighter more efficient commercial aircraft and automobiles.

REFERENCES:

1. "Dynamic Fatigue of Carbon-Carbon Thermal Protection Systems" H. C. Croop, M. P. Camden, K. R. Wentz, 37th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference AIAA-96-1618, Salt Lake City, Utah April 15 - April 17, 1996.
2. "Thermo-Mechanical Evaluation of Carbon-Carbon Primary Structure for SSTO Vehicles" H. C. Croop, H.B. Lowndes III, S. E. Haun and C. A. Barthel Space Technology & Applications International Forum, Albuquerque, New Mexico, 25-29 January 1998.
3. "High Cycle Fatigue Testing of Blackglas™ Composite Coupons using a Half Sine Clamp" M. P. Camden, D. B. Paul, L. W. Simmons, H. F. Wolfe, L. W. Byrd, R. R. Batzer 68th Shock and Vibration Symposium Hunt Valley, Maryland Nov 3 - 7, 1997

KEYWORDS: Hot Structures, Cryogenic Tanks, Military Space Plane, Hypervelocity Vehicles, Space Operation Vehicles, Ceramic Matrix Composites, Activity Cooled Structures, Thermal Protection Systems

AF99-268 TITLE: Deformation Measurement for Conformal Loadbearing Antenna Structure Arrays

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop a structural deformation measurement system for large high frequency conformal loadbearing antenna structure arrays.

DESCRIPTION: The Air Force is pursuing the development of conformal loadbearing antenna structure (CLAS). CLAS features radio frequency (RF) antennas embedded in the loadbearing skin of aircraft structure. This concept provides improved antenna performance from increased aperture size as well as structural integrity, weight, cost, and signature payoffs. This solicitation is focused on a need to develop a system capable of measuring the deformation or displacements of large high frequency CLAS arrays induced by flight. The displacements will be used for real time array phase compensation. The goal of this solicitation is to develop an environmentally robust displacement measurement system capable of operation in electromagnetic fields characteristic of RF transmission and reception. This measurement system must provide the accuracy required for a CLAS array phase compensation system. In addition, the system must be non-obtrusive, structurally embeddable, and capable of surviving manufacture processing and the flight environment.

PHASE I: Demonstrate the feasibility of an approach to accurately measure displacements of a large high frequency CLAS array.

PHASE II:Demonstrate the performance and structural integrity of the displacement measurement system in a representative CLAS component.

PHASE III DUAL USE APPLICATION: This technology will be applicable to all military air vehicles and space systems using large high frequency RF apertures. Commercially, this technology will broaden the application of CLAS technology to airline and civil aircraft to provide efficient high frequency RF communications for passengers' personal computing, data communications, video, cellular phones, high definition television, and more. This technology will also benefit large spaced based antenna arrays for commercial satellite systems.

REFERENCES: "Structurally Integrated, Conformal Smart-Skin Antennas for Military Aircraft - Issues and Payoffs," Conference Proceedings, Society of Photo-Optical Instrumentation Engineers, Orlando, Florida, 13-18 February 1994.

KEYWORDS: Arrays, Antenna, Deflection, Structures, Deformation, Measurement

AF99-269 TITLE: Unstable Random Vibration Response of Composite Panels

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop analytical expressions for the unstable random vibration response of composite panels with simultaneous thermal and acoustic loads.

DESCRIPTION: The assessment of the fatigue life and the effects on aerodynamic shapes for the thermal acoustic loads on supersonic and hypersonic vehicle structurrs is needed. Previous efforts made various attempts at solving the plate stability problems. New approaches to the instability problem are sought. The solution procedure should account for the interdependency between the thermal effects and the acoustic structural response. Consideration should be given to the critical temperature change that produces plate buckling, temperature gradients along the edge and improvements in numerical integration methods and iterative procedures. The analytical techniques should and include the use of high temperature composite materials such as ceramic matrix composites.

PHASE I: Develop new analytical methods for unstable composite plates.

PHASE II: Demonstrate the new analytical method by example and validate using a database.

PHASE III DUAL-USE APPLICATIONS: Military space plane and the high speed civil transport.

REFERENCES:

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KEYWORDS: Snap Through, Composite Plates, Thermal Buckling, Random Vibrations, Acoustic Excitation, Probability Density Functions

AF99-271 TITLE: Modern Methods for Flying Qualities and Stability and Control Analysis

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop interactive tool for UCAV stability and control/flying qualities of hypersonic control effectiveness.

DESCRIPTION: Currently available software for assessing the flying qualities or stability and control characteristics of UCAV is typically run in a "batch" mode on a PC or workstation.. Within this environment, there is no capability for interactive analysis with simultaneous online documentation of the underlying theory used to generate the data. It is also cumbersome to generate the required data for flight simulation using current software. New configurations could be studied in a much more efficient manner if this capability was available. This would reduce flight control system development cost. For hypersonic vehicles, there is a need to develop alternate control effectors based on flow control.

PHASE I: Expectations for this phase would be a working version of a tool that performed calculations for one vehicle component with associated on-line documentation. For a hypersonic control effector, analytic predictions of effectiveness and costs should be available.

PHASE II: Expectations for this phase would be an interactive tool applicable to a complete vehicle including a flight control system. For a hypersonic control effector, wind tunnel tests and possibly fabrication of a full-scale device would be expected.

PHASE III DUAL USE APPLICATIONS: The flying qualities tool could be used for UAVs of any type, both military and civilian, while the stability and control tool could be used for UAVs or manned vehicles. The high cost of proposed commercial uses of space could be reduced with innovative hypersonic configurations or control effectors.

REFERENCES: Control Dynamics Branch home page, http://www.wl.wpafb.af.mil/flight/fed/fige

KEYWORDS: Flying Qualities, Hypersonic Control, Stability and Control, Uninhabited Air Vehicles, Unmanned Combat Air Vehicles

AF99-272 TITLE: Aeromechanics for Future Aircraft Technology Enhancement

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop aeromechanics for affordable 21st century aircraft with significant improved speed, maneuverability, range and survivability.

DESCRIPTION: The United States Air Force has a vital interest in the development of manned and unmanned aircraft with significant advancement in flight performance and mission effectiveness. These advanced vehicles will rely on innovation in aeromechanics technology to achieve new levels of speed, maneuverability, range, payload capability, life cycle cost and rapid design development. Advancements are needed in the following areas: a) accurate engineering design methods for determining aerodynamic characteristics and flight performance of unconventional aircraft, b) accurate, efficient computational fluid dynamics methods to describe both steady and unsteady airflow about air vehicles, c) flow control devices which can be used to reduce drag or improve inlet or nozzle performance, d) efficient integration of inlets and nozzles and e) innovative aircraft configurations which produce advanced performance capabilities for a wide range of air vehicles operating in the subsonic through hypersonic flow regimes.

PHASE I: Define the proposed concept, outline the basic principles, and establish the method of solution. Present an example of the advanced performance which will result from the technology. Determine the risk and extent of improvement over existing methods.

PHASE II:Build a prototype application of the equipment or software. Demonstrate the advanced technology under actual engineering conditions.

PHASE III DUAL USE APPLICATIONS: Improved performance and safety of commercial and private aircraft will be realized with the application of this technology. New areas of commercial growth will result from aircraft design tools which allow fast and accurate development of air vehicles to respond to aircraft needs around the world. Examples are devices which allow aircraft to operate from remote fields, carry large payloads at low cost, and are economical to produce and operate. New aerodynamic analysis tools will improve education methods and allow industry to produce with lower initial investment.

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2. "Propulsion Integration Issues for 21st Century Fighter Aircraft." Marvin Gridley and Steven Walker, Paper #42 in Proceedings of AGARD Propulsion Energetics Panel, Seattle, Washington, Sep 1995. (96N36606)

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KEYWORDS: Inlets, Nozzles, Hypersonics, Integration, Aerodynamics, Aeromechanics, Active Flow Control, Aircraft Configurations, Computational Fluid Dynamics (CFD)

AF99-273 TITLE: Hypersonic Flow Control

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop methods and devices to modify aerospace vehicle airflows to control drag, heating, and maneuverability.

DESCRIPTION: Sustained hypersonic flight offers potential revolutionary improvements in warfighting and space launch. Limiting factors in vehicle performance include aerodynamic heating, pressure and viscous drag, and maneuverability. Flow control methods and hardware developed for subsonic and supersonic flows are generally ill-adapted to the hypersonic flight environment. Active and passive flow control methods which are survivable, take advantage of the unique characteristics of hypersonic airflow, and which may be integrated into hypersonic vehicles, are sought.

PHASE I: Define the physical mechanisms by which flow control is effected and develop relationships (theoretical or empirical) between the input and desired output. Conduct or at least define tests demonstrating the feasibility of the method. Present concepts for vehicle integration and maintainability, and present an example of the effect of the flow control method on vehicle performance.

PHASE II:Construct a bench-scale flow control system using methods defined in Phase I. Demonstrate the concept in laboratory tests. Analyze the costs and benefits of the technique as applied to an aerospace vehicle.

PHASE III DUAL USE APPLICATIONS: Flow control concepts developed under Phases I and II may potentially be applied to civilian space launch and high speed air vehicles. Flow control hardware which operates in hypersonic flight may have civilian application in high temperature environments such as furnaces, engines, materials processing, and manufacturing.

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1. Future Aerospace Technology in the Service of the Alliance, Volume 3, Sustained Hypersonic Flight, AGARD-CP-600 Vol. 3, December 1997

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KEYWORDS: Drag, Plasma, Acoustics, Hypersonics, Aerodynamics, Active Flow Control, Aerodynamics Heating, Boundary Layer Transition, Multidisciplinary Analysis, Multidisciplinary Optimization

AF99-274 TITLE: High Temperature, Structural Load Bearing Heat Exchanger Technologies

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop technologies to transfer aerospace vehicle heat loads through high temperature, and structural load bearing heat exchangers.

DESCRIPTION: Heat exchanger maximum operating temperature and packaging constraints (volume/weight) onboard aerospace vehicles have always been a challenge. Current heat exchanger requirements limit the use of high temperature materials and efficient manifold designs. With increased emphasis on aerospace vehicle platform size and range, this problem has become more critical. The emphasis in design is now becoming the development of heat exchangers with decreased weight and volume which operate at much higher temperatures. This will be especially critical for the next generation aerospace vehicles that utilize heat exchangers to transfer heat from exhaust washed and leading edge structures. One solution to this problem is to develop a heat exchanger which functions as both the manifold, or container for the heat exchanger core, and as an integral structural member. In addition to weight and volume reductions, this approach should improve system-level heat management by improving thermal contact with structural

elements which are either a heat source (e.g., leading edge) or a heat sink (e.g., outer skin surface). These benefits have the potential to improve aerospace stealth characteristics, dynamic stiffness, and provide greater range or payload capabilities. The heat exchangers will be operating with fluid/surface temperatures in the range of 300-1700 Deg F. The effort to be performed will develop innovative concepts for high temperature, structural load bearing heat exchangers providing controlled cooling in aerospace vehicles. This technology will be critical for aerospace vehicles.

PHASE I: During Phase I, analysis and conceptual design work will be performed to evaluate the feasibility of developing a high temperature and structural load bearing heat exchanger. This will include consideration of potential acoustic and vibration loads. Analysis of heat exchangers fabricated (both core and manifold shell) from various high temperature materials shall be included. The analysis and conceptual design will also address the compatibility of developed concepts with the aerospace vehicle and its subsystems. The design will show sufficient technology maturity for orderly development into aerospace systems with compatible environmental factors. The Phase I work will produce a competent technical report and plans for experimental development in a proposed Phase II effort.

PHASE II:This phase continues the necessary analytical work and provides experimental verification of predicted heat exchanger operating capabilities for high temperature and structural loading materials. Laboratory simulation of typical aerospace vehicle operating conditions will evaluate heat exchanger performance at various fluid inlet flow rates, temperatures, and heat loads. Benefits to be gained from the use of the high temperature, structural load bearing heat exchangers will be quantitatively established for various aerospace applications to prepare for possible commercial development of the heat exchanger. A comprehensive technical report will document all of the work conducted, a final optimized design will be completed, and a demonstration heat exchanger will be fabricated.

PHASE III DUAL USE APPLICATIONS: Dual use commercialization will be considered in all phases of this effort. Potential commercial applications include in-flight cooling on the High Speed Civil Transport (HSCT), industrial process heat exchangers, and integrated cooling for commercial satellite launch systems.

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5. "Load-Bearing Capacity of Heat Exchange Pipes of Polymer," Chemical and Petroleum Engineering (Journal Article: v 20 n 7-8 Jul |Aug 1984 p 330-331), Kuz'menko, Journal Announcement: 8509, E. I. Number: EI85051687.

KEYWORDS: Load Bearing Structure, Leading Edge Structures, Aircraft/Subsystem Cooling, Exhaust Nozzle Heat Transfer, Launch Vehicle Heat Transfer, High Thermal Conductivity Materials

AF99-275 TITLE: Instantaneous Temperature Measurement System

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Development of robust temperature measurement systems with micro-second response times.

DESCRIPTION: There is currently no commercially available temperature sensor that can react fast enough to quantify nearly instantaneous (1 microsecond) temperature changes. This limitation prevents the accurate determination of temperature increases behind a shockwave due to an explosion in a fluid-filled medium. This effort involves the development of a system that can quantify these rapid temperature changes behind such an explosive shock wave. The system will be used by the Air Force Research Laboratory to describe fully the temperature fluctuations behind a 3 dimensional shock wave in a large (5 ft diameter, approximately 5 ft high) open-top, fluid-filled container with transparent viewports. The shock wave will be generated by a High Explosive Incendiary (HEI) shell detonation near the center of the container. Due to the explosive reactants, detonation of the HEI shell renders the fluid opaque. Because of the envisioned service environment, the system must be very robust. For an in-tank system, probes must be capable of surviving an instantaneous shock wave pressure of approximately 30 ksi, must not be effected by the fluid environment and must be able to use several gauges simultaneously to obtain an accurate description of the 3-D temperature change.

For an out-of-tank system, the equipment must be able to work through the thick glass viewports, must be water resistant and must not be affected by the opacity of the fluid behind the shock wave. For all systems, the temperature sensors must have a response time of approximately 1 microsecond and must be resistant to severe electro-magnetic noise. The overall system must be able to record up to 0.1 seconds of data and the temperature reading must be as accurate as possible up to 2000oC. The preferred system would also be able to adapt to any given test configuration (i.e. closed container, aircraft wingbox, 1-D shock tube, no transparent viewports, etc.) The system will be used to validate hydrocodes currently used to simulate hydraulic ram phenomena.

PHASE I: A prototype system will be designed to capture rapid temperature fluctuations behind a shock wave. The design will be supported numerically and through proof-of-concept tests.

PHASE II:A prototype temperature measurement system will be developed, tested and delivered. The system will be able to characterize fully the rapid temperature fluctuations behind a shock wave in a fluid-filled environment.

PHASE III DUAL USE APPLICATIONS: A very robust instantaneous-temperature-measurement system would be a useful tool to any industry involved in combustion processes. This tool could potentially aid automakers in designing fuel injectors or combustion chambers that would optimize fuel distribution and burn. It could also be used by jet engine manufacturers to help visualize flow throughout an engine or to optimize the combustion process.

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2. Kidd, S. R, Barton, J. S., and Jones, J. D., "Demonstration of an optical fibre probe for high bandwidth thermal measurements in turbomachinery," Proceedings of the 10th International Conference on Optical Fibre Sensors, 10th, Society of Photo-Optical Instrumentation

KEYWORDS: Explosion, Shock Wave, EMI Resistant, Instrumentation, Fluid-filled Container, Temperature Measurement

AF99-276 TITLE: Enhanced Conduction, Radiation, and Ionic Heat Transfer for Aerospace Vehicles

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop high conductivity solids, enhanced radiation, and/or ionic transport for heat transfer in aerospace vehicles.

DESCRIPTION: Thermal management onboard flight vehicles and space satellites is always a challenge. Standard approaches require substantial mass and power, both of which affect total vehicle size, payload and range. Continued growth in the density of electronics and other items mounted in the vehicles, combined with new operational needs such as reusable space launch systems or hybrid air/space vehicles, and long duration flight of uninhabited air vehicles (UAV), requires the development of new and innovative methods for heat transfer. Total heat loads for long endurance UAVs are expected to be in the 15 to 50 kW range. Internal heat loads for other aircraft, reusable launch systems and satellites will vary widely depending on the type of system and the configuration. Methods to transfer heat from dense sources to the structure or skin of the vehicle, or to thermally isolate equipment from hot structure, need to be simple, dependable, lightweight, and efficient. Reduction or elimination of moving parts is an important goal. Thermal conduction through solids, use of dissimilar metals, and use of ion transport are among the candidate approaches to consider. Coatings and surface treatments will, of course, also have an effect. Avoiding the use of convective fluids can simplify the thermal management equipment and prevent problems in the weightless environment of space. Proposed technical approaches for this topic must show promise of significantly improved performance compared to thermal conduction in ordinary solids but without the use of convective fluids. This topic represents critical subsystem technology for air vehicles and space vehicles.

PHASE I: Analysis, conceptual design work, and optional simple experiments will be performed to evaluate the feasibility of developing the selected heat transfer method(s). This will include analysis of the relative merit of the new, innovative approach in comparison to conventional heat transfer for conditions of interest in piloted military aircraft and UAV's (0 to 60,000 feet altitude) and other aerospace vehicles. The analysis and conceptual design will also address the compatibility of developed technologies with the vehicle and its subsystems. The design will show sufficient technology maturity, practicality, and payoff benefit for orderly development in the next phase of effort. The Phase I work will produce a competent technical report and plans for experimental development in a proposed Phase II effort.

PHASE II:This phase continues the necessary analytical work and provides experimental verification of predicted heat transfer capacities for the selected approach. Laboratory simulation of typical operating conditions will evaluate performance at various altitudes and heat loads. Any environmental restrictions will be assessed. Benefits to be gained from the use of the new approach will be quantitatively established for different potential applications to prepare for possible commercial development of the system. A comprehensive technical report will document all of the work conducted, a final optimized design will be completed, and a demonstration device will be fabricated and tested.

PHASE III DUAL USE APPLICATIONS: Dual-use commercialization will be considered in all phases of this effort. Potential commercial applications include in-flight cooling on the High Speed Civil Transport (HSCT), general aviation aircraft, large facility cooling (e.g., air conditioning), and commercially developed reusable space launch systems.

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1. "Preliminary Design and Analysis of an Advanced Heat-Rejection System for an Extreme Altitude Advanced Variable Cycle Diesel Engine Installed in a High-Altitude Advanced Research Platform," Johnston, R. P. DieselDyne Corp., Morrow, OH., Report No.: NAS 1.26:186021; H-1775; NASA-CR-186021, Jul 92, NTIS Accession Number: N92-29427/1/XAB.
2. "Development of a Self Contained Heat Rejection Module, Phase 2 and 3" (Final Report), Fleming, M. L., Vought Corp., Dallas, Tex. Systems Div. Report No.: NASA-CR-151109; T211-RP-032, 17 Aug 76, NTIS Accession Number: N77-12068/1.
3. "Integrated Engine Inlet Thermal Anti-Icing and Environmental Control System (TAI/ECS)," Shaw, A. D., Boeing Commercial Airplane Co., SAE Paper 760517 (available from AIAA Tech. Library), May 76.
4. "Nonmetallic Crystals With High Thermal Conductivity," Slack, G. A., General Electric Research & Development Center, J. of the Physics and Chemistry of Solids, Vol. 34, No. 2, pp. 321-335, Feb. 73.
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KEYWORDS: Ion Transport, Heat Rejection, Dissimilar Metal Devices, Aircraft Subsystem Cooling, Launch Vehicle Heat Transfer, High Thermal Conductivity Solids

AF99-277 TITLE: Enhanced Dry Chemical Fire-Extinguishing Agents

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Development of an enhanced dry chemical fire-extinguishing agent.

DESCRIPTION: Simple dry chemical fire suppressants such as sodium bicarbonate and ammonium phosphate are highly effective in extinguishing fires and in suppressing explosions. These materials have little environmental or toxicological impacts, and provide rapid-fire knockdown. Their disadvantages include (a) no inhibiting atmosphere after discharge, (b) no direct cooling of surfaces or fuel, (c) possible secondary damage, (d) cleanup, and (e) visual obscuration. Modification of dry chemical extinguishants offer an opportunity for major enhancement of suppression and inertion performance by providing longer-term suppression capability and/or reducing the amount of agent needed. Dramatic improvements in dry agents may allow their use as replacements for ozone depleting halons in fire suppression applications. Enhancement of dry chemical suppression and inertion can be achieved by particle size reduction; however, most methods for generating small particulates (e.g., pyrotechnically generated aerosols) have major drawbacks, and performance enhancement is insufficient to allow substitution for halons in most applications. Performance enhancement is particularly promising through modification of surface morphology or bulk particulate chemistry changes (e.g., doping).

PHASE I: Identify and assess mechanisms for enhancing dry chemical suppression. Prepare modified agents and conduct laboratory studies to identify the most promising technologies.

PHASE II: Develop processes for production of enhanced dry chemical suppressants and perform a proof of concept demonstration of the enhanced dry chemical suppressants.

PHASE III DUAL USE APPLICATIONS: Develop and demonstrate large scale processes for production of the enhanced dry agents. All commercial facilities and industries where rapid fire detection and suppression would increase the survivability of people and protection of resources. All commercial facilities would include but not limited to the automotive industry, commercial cruise lines and/or other sea transportation.

REFERENCES: Ewing, C. T., Faith, F. R., Hughes, J. T., and Carhart, H. W., "Flame Extinguishment Properties of Dry Chemicals: Extinction Concentrations For Small Diffusion Pan Fires," Fire Technology, Vol. 25, pp. 134-149, May 1989.

KEYWORDS: Halon, Dry Chemicals, Inertion Agents, Fire Suppressants

AF99-278 TITLE: Advanced Stochastic Techniques for Finite Element Vulnerability, Fatigue, Corrosion Simulation

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop efficient methods for stochastic modeling involving finite element damage simulations common to vulnerability, fatigue, and corrosion.

DESCRIPTION: The ever increasing reliance of Department of Defense planners and developers on computer simulation and modeling places a premium on increasing the computational efficiency of these methods. Monte Carlo methods, for example, typically consume extensive computational resources. This research deals with the rapid generation and execution and statistical post processing of multiple finite element models of structures for purposes of monte carlo simulation of survivability/vulnerability, fatigue and corrosion damage.

A number of technology areas require that multiple (a number sufficient for statistical confidence) finite element models of damaged structures be analyzed in the context of a Monte Carlo Simulation. Important cases of this situation which require identical types of analysis include vulnerability analysis of weapon effects on aircraft structures, effects of multi-site fatique damage, residual strength of structures subjected to intergranular corrosion, and large strain deformation of materials and structures incurring internal damage. In these problems a basic structure is repeatedly analyzed subjected to fixed loads in the presence of statistical realizations of a variable load distribution, number of discrete loads and corresponding load application points, a size and number density distribution of ideal geometrical slits, penny shaped cracks or cutouts simulating damage due to a variety of causes such as fragment perforations, fatigue crack populations, or populations of intergranular cracks. In all these cases a parameter (order parameter) associated with the load or damage distributions can reach a critical value at which the structure incurs a complete loss of its strength or stiffness. The order parameter may be product life and the growth of the damage modeled by some stochastic process model such as DLA, Diffusion Limited Aggregation. A finite element model is unable to analyze this state due to the infinitesimal size of the elements required. In the vicinity of this critical value, it is known that the average retained strength or stiffness fits a power law function of the difference of the order parameter from its critical value. Subsequently, performing a Monte Carlo Analysis of the structure in the vicinity of the critical parameter (critical phase transition) will yield results, the average of which must be fitted to a power law curve to infer the critical parameter value as well as the exponent of this variation. The asymptotic behavior near the critical point is known to be independent of the geometry of the damage for example. The Government can realize substantial savings if a single efficient common analysis approach is made available to all these ostensibly separate areas which require performance of the same type of finite element analysis of geometrically modelled damage. It is also of interest to deduce the variance of the statistical distribution for use by designers of such structures and the associated power laws describing them.

PHASE I: Analyze current methods and desired future capability for stochastic modeling in the disciplines subject of this research, especially where computer resources required or turn around time are excessive. Outline techniques with potential for increasing the efficiency and reducing turn around time for these kinds of analysis.

It is desired that the investigators demonstrate the promise of an eventual capability by analyzing the sample problem of the residual strength and stiffness of a circular plate of uniform thickness supported on a clamped outer circular boundary and loaded by a uniform normal load while containing a random distribution of holes normal and through its thickness. The average variation and variance of the stiffness is desired and the value of the critical void fraction and power law exponents as the critical void fraction is approached. The material cases shall be assumed to be brittle and linear elastic combined with hardening plasticity. The problem may be analyzed by current techniques with the option of incorporating some solution speed up techniques and documenting the order of magnitude advantages which will be realized in Phase II.

PHASE II: A prototype model design incorporating the principal types of stochastic analyses involving Monte Carlo Techniques in which finite element models from the disciplines of interest are used will be developed.

PHASE III DUAL USE APPLICATIONS: Commercial, manufacturing and government concerns make extensive use of stochastic modeling techniques. Fatigue and Corrosion Life Estimation and Combat Structural Vulnerability Assessment applications abound. Incidence of product liability litigation fuels demand for commercial sector stochastic modeling. More efficient stochastic modeling methods will reduce costs and increase market potential.

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1) Nelson, Barry L., "Stochastic Modeling: Analysis and Simulation", McGraw-Hill, Inc. (1995) , ISBN 0-07-046213-5.
2) Krajcinovic, Dusan, "Damage Mechanics", Elsevier Science B. V., (1996), ISBN 0-444-82349-2.
3) Stauffer, Dietrich, and Ammon Aharony, "Introduction to Percolation Theory", Taylor and Francis Ltd., (1992), ISBN 0-7484-0027-3.

KEYWORDS: Damage Mechanics, Percolation Theory, Monte Carlo Techniques, Universal Scaling Laws, Finite Element Analysis, Critical Phase Transition Points

AF99-279 TITLE: Active Shock-Boundary Layer Control for Drag Reduction

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Improved Aircraft Cruise and Maneuver L/D Performance.

DESCRIPTION: The systematic reduction of aircraft wing drag can lead to L/D improvements exceeding 25% in both the cruise and maneuver flight regimes. Prior Air Force efforts on aircraft wing drag reduction have focused on laminar flow control, turbulent skin friction reduction and induced drag minimization. All of this research has been successful, in varying degrees. However, none of the profile drag reduction concepts developed have yet been transitioned to aircraft fleet applications, and only the winglet concept of induced drag reduction now appears in the active transport aircraft fleet. A fruitful area for future wing drag research, with a high transition potential, is shock-boundary layer interaction control. Active flow control devices: micro-electromechanical systems (MEMS), micro vortex generators and shaped memory alloy (SMA) devices to mention several, have evolved to the point that it is now practical to provide appropriate active aerodynamic control on a wing surface that will reduce the shock- boundary layer interaction drag increment under both cruise and maneuver flight conditions. Furthermore, analytical tools are available that can be used to accurately position the active shock-boundary layer control devices to maximize wing/airfoil L/D performance improvement. The thrust of this project is the development, demonstration and aerodynamic performance validation of an active shock-boundary layer control system(s) that effectively reduces wing drag during cruise (first priority) and maneuver (second priority).

PHASE I: Analytically develop an active shock-boundary layer control system(s) designed to improve aircraft wing L/D performance. Flow control effector concepts utilized in the system must have a developed experimental data base.

PHASE II: Active shock-boundary layer control system(s) experimental performance validation, on a representative aircraft airfoil/wing wind tunnel model.

PHASE III DUAL USE APPLICATIONS:
Military applications of the Phase II developed shock-boundary layer L/D improvement system include transport aircraft wings, cruise drag reduction and combat aircraft wing applications, both cruise drag reduction and maneuver L/D improvement. Commercial application candidates for this technology include high speed general aviation aircraft and commercial transport aircraft.

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3. Saddoughi, S.G., "Experimental Investigations of On-Demand Vortex Generators," Center for Turbulence Research, Annual Research Briefs, 1994, pp. 197-203.

KEYWORDS: Aerodynamics, Drag Reduction, Neural Network, MEMS Flow Effector, Active Flow Control, Shock-Boundary Layer Interaction

AF99-280 TITLE: Innovative Techniques for Prediction and Control of Dynamic Loads

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Investigate new and novel concepts for predicting and controlling dynamic loads on aircraft.

DESCRIPTION: Many aircraft in the current fleet have had or are experiencing failures due to high dynamic loads. Acoustic loads and buffet can significantly reduce the life of the structure and lead to frequent inspection and costly repair or replacement of various structure on the aircraft. New unique and novel concepts or approaches are needed to ensure that current technology is fully exploited for the wide variety of acoustic and dynamic environments. Prediction techniques are needed that are computationally efficient yet capture the important flow physics (e.g., viscous effects, separation, etc.). Current active control research can be exploited to control these environments and hence reduce the related fatigue causing structural damage. Numerous actuators have been tested to date with very promising results. These include both flow control for acoustic suppression and piezoelectric actuators for structural vibration control. Flow control actuators include fluidic jet or nozzle, flaps, thermal energy, and other devices, which can inject time dependent energy into the flow and reduce the acoustic levels.

PHASE I: Determine the technical merit and feasibility of the approach.

PHASE II: Demonstrate the selected analytical method or control technique.

PHASE III DUAL USE APPLICATION: Methodology could be incorporated into commercial software for use by the automotive industry, commercial aircraft companies, or other industries. Control devices could be used in any industry with dynamic load or acoustic noise problems.

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KEYWORDS: Loads, Control, Dynamics, Acoustics, Computational, Aeroelasticity

AF99-284 TITLE: Rapid Charging for Electric Ground Support Equipment

TECHNOLOGY AREA: Surface/Under Surface Vehicles/Ground Vehicles

OBJECTIVE: Develop a standardized rapid charging system to enable electric ground support equipment to meet mission requirements with minimal downtime for battery charging.

DESCRIPTION: Ground support vehicles range in size from forklifts to aircraft tow tractors and are used to support flight-line operations. They are conventionally powered by internal combustion diesel or gasoline engines. Hybrid electric drive and electric drive systems are currently under development which offer constant torque and considerable environmental, reliability and maintainability benefits over internal combustion drive systems. Unfortunately, electric vehicles are range limited, and hybrid electric vehicles still require an onboard Internal Combustion Engine (ICE) to charge the batteries. The purpose of this project is to develop a standardized rapid charger system that can be used on ground support vehicles to increase their availability, and ultimately increase the utility of electric drive systems in ground support equipment and vehicles. Additionally this charging system should be able to charge all types of electric flightline equipment, eliminating different charger configurations for different equipment types. A rapid charge system would eliminate the need for the hybrid ICE and overcome the range limitations inherent in current electric vehicles. This will result in making electric vehicles more suitable for a variety of applications and increasing their utility when compared to conventional ICE vehicles.

PHASE I: Assess feasibility, compare various battery and charging technologies, and identify candidate systems for full evaluation. Current electric ground support equipment and vehicles range in size from electric forklifts with 36 VDC battery packs to aircraft tow tractors with 600 VDC battery packs. A prototype battery pack and charger may be tested in this phase.

PHASE II: Fully research and develop a rapid charging system that can charge the full range of electrically driven material handling equipment and vehicles. The charger may be capable of charging multiple vehicles at the same time. Reliability, maintainability, environmental impact and cost effectiveness of developed technology shall be addressed/ evaluated in this phase.

PHASE III DUAL USE APPLICATIONS: The commercial benefits of this project are tremendous. Rapid charging capability overcomes the current range limitations of electric drive systems. This limitation is the single biggest obstacle in utilizing electric over conventional ICE equipment and vehicles. Replacing conventional internal combustion engines with rapidly charged electric engines has broad applications in the commercial automotive, airline, and marine industries.

REFERENCE: Statement of Objectives (SOO) for Hybrid Electric Tow Tractor

KEYWORDS: Batteries, Rapid Charging, Electric Vehicles

AF99-285 TITLE: Cleaner for Removing Grease and Heavy Soil from Machine Parts

TECHNOLOGY AREA: Environmental Quality/Civil Engineering

OBJECTIVE: Develop a low cost, environmentally and health compliant cleaner for degreasing and cleaning machine parts.

DESCRIPTION: Field level maintenance personnel are required to clean weapon system components, such as aircraft guns and bomb ejector racks, to facilitate various maintenance and inspection procedures. Historically, Methyl Ethyl Ketone (MEK), Stoddard solvent, or highly refined aliphatic hydrocarbon compounds have been used. While effective, these chemicals are either

environmentally or health and safety incompatible. Recent cleaners, promoted as 'environmentally friendly' (i.e., water-based), perform poorly and cause flash corrosion. An effective cleaner that can degrease and clean heavily soiled areas in a cost-effective, environmentally compliant, and health and safety compliant manner is required. The weapons systems involved are standard Department of Defense (DoD) weapons listed in the Technical Orders series 11W1 and 11B29 -- applied to high strength steel, corrosion resistant steel, aluminum, composite substrates, and rubber. This cleaner should have no deleterious effects on any of the materials listed.

PHASE I: Assess feasibility; compare various cleaning formulations; consider environmental, health, and safety aspects; and perform tests to validate the formula for full evaluation. A prototype cleaner may be formulated and demonstrated in this phase.

PHASE II:Fully research and formulate a cleaner for controlled testing. Reliability, evaluation of potential damage to aerospace materials, and cost-effectiveness of the developed technology shall be evaluated in this phase.

PHASE III DUAL USE APPLICATIONS: Private industry and government agencies have an aerospace and non-aerospace need for an environmentally friendly cleaner. There is great potential for adapting or adopting the cleaner for use on automobile engines, aircraft engines, or any other heavily soiled machine parts.

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1) Technical Order 11B29-3-25-2, "Field Maintenance and Overhaul Instructions"
2) Technical Order 11W1-12-10-2, "Intermediate Maintenance 30mm Gun Assembly"
3) ADA221286 [EG&G Idaho Inc.], "Substitution of Wax and Grease Cleaners with Biodegradable Solvents" Phase I Part 4. Wikoff, P.M., Schober, R.K. (et. al), Sep. 1989, 228 p.
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KEYWORDS: Soiled, Cleaner, Formula, Degrease, Bioenvironmental

AF99-286 TITLE: Portable Accumlated Fatigue Damage Inspection and Imaging System

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop a portable inspection/imaging system to identify accumulated fatigue damage prior to crack initiation.

DESCRIPTION: Current force-management policy regarding aircraft structural integrity involves fracture mechanics concepts, nondestructive inspection, and crack repair techniques. The impact of cracks on structural integrity is considered only during the period of crack growth life (i.e., after a crack has initiated.) Therefore, during the life cycle, force-management efforts are applied after accumulated fatigue damage has already manifested as a detectable crack. However, fatigue damage accumulates in service due to cyclic loading. After a lengthy period of incubation, accumulated fatigue damage manifests itself as an incipient fatigue crack, which then grows at a rate proportional to the prevailing service conditions. This period of crack growth is referred to as the crack growth life. The preceding incubation period, in which fatigue damage is accumulating but is not otherwise manifested, is referred to as the crack initiation life. Since the typical crack initiation life period is substantially longer than the crack growth life period, our current force-management approach is constrained by our inability to quantitatively analyze accumulated fatigue damage prior to crack initiation. This topic proposes to develop a concept/technology to identify accumulated fatigue damage prior to crack initiation. Therefore, this proposed concept/technology, by detecting and quantifying accumulated fatigue damage in the crack initiation life period, will allow force-management actions to be employed much sooner and provide the data and understanding that can be employed to extend the life of the pertinent structures well beyond what the current technologies and policies allow. This concept/technology shall be portable and designed primarily for use on high-strength aluminum alloy structures.

PHASE I: Assess feasibility, evaluate, and test candidate concepts and technologies for subsequent engineering development. Develop a prototype, which will demonstrate the capability to empirically and quantitatively identify accumulated fatigue damage in portable packaging.

PHASE II:The concept will be developed to full capability to include the ability to provide quantitative accumulated fatigue damage analysis and near real-time imaging capability. A production prototype will be manufactured and tested by employing DOE criteria to ensure that the capability is fully documented with acceptable levels of precision and accuracy. A conceptual model will be developed to describe the impact of this concept on current force-management policy and techniques.

PHASE III DUAL USE APPLICATIONS: This capability is not only needed by the other DoD services and governmental agencies, such as the FAA and NASA, but also by the commercial aviation industry and the airlines. There is a substantial potential for commercialization if this effort is successful in developing viable technological improvements over the current methodologies.

REFERENCES: "Accumulated Fatigue Damage" Memo, WR-ALC/TIEDM

KEYWORDS: Imaging, Nondestructive Inspection, Accumlated Fatigue Damage

AF99-287 TITLE: Hybrid Electric Power System for Aircraft Loaders

TECHNOLOGY AREA: Surface/Under Surface Vehicles/Ground Vehicles

OBJECTIVE: Develop a hybrid electric power system to provide propulsion power and supply lift and tilt power for aircraft loaders.

DESCRIPTION: Aircraft loaders are conventionally powered by diesel internal combustion engines and utilize hydraulic systems to provide lift and tilt capabilities to the loader deck. Failures of the hydraulic systems are frequent, causing more than half of all loader failures. However, hydraulics have historically been the only choice for applications requiring high-power energy transfer, such as aircraft loaders. Recent developments in high-power electrical controllers indicate the potential for replacing hydraulic systems. This topic proposes to develop a hybrid electrical system for use in aircraft loaders. The system would consist of a hybrid electric power train for vehicle propulsion, with electric motors and actuators capable of meeting lifting requirements. Hybrid power trains for vehicle propulsion have been demonstrated as technically feasible in several DARPA, DOE and Air Force projects. An ancillary benefit of the hybrid drive train is the availability of a large amount of electrical energy. This energy can be applied to the electric motors and actuators for lifting and tilting the loader deck. This hybrid electrical system will provide reliability, maintainability, and environmental benefits over existing hydraulic systems.

PHASE I: Assess feasibility, compare various concepts, and identify candidate systems for full evaluation. A prototype lifting system may be developed in this phase.

PHASE II: Fully research and develop a prototype hybrid electric driven aircraft loader with electrically driven lift and tilt systems. The loader shall be capable of lifting loads up to 25,000 pounds to a height of 18.5 feet. Reliability, maintainability, environmental impact and cost effectiveness of developed technology shall be addressed/evaluated in this phase.

PHASE III DUAL USE APPLICATIONS: Replacing hydraulic systems with high-power electrical systems has application across the commercial sector. Vehicles that could benefit from this technology include commercial aircraft loaders, dump trucks, garbage trucks and any vehicle that uses hydraulics. Fixed hydraulic applications will also benefit from this program.

REFERENCES:
(1) T.O. 36M2-3-33-1, 25K Southwest Loader;
(2) Statement of Objectives for Next Generation Small Loader.

KEYWORDS: Hydraulics, Electric Motors, Hybrid Electric, Electric Actuators

AF99-288 TITLE: New Material for O-Rings and Seals in Halon 1202 Pressurized Systems

TECHNOLOGY AREA: Environmental Quality/Civil Engineering

OBJECTIVE: Develop a low cost, environmentally compliant material for o-rings and seals in pressurized Halon 1202 applications.

DESCRIPTION: Depot level maintenance personnel are required to overhaul fire extinguishers installed in Air Force weapon systems, such as the C-130 and C-141 aircraft, which are pressurized with Halon 1202. The overhaul process, described in TO 13F6-12-3, must have a minimal impact on the environment to comply with the Clean Air Act. The o-rings and seals currently used in the overhaul process are made with materials that deteriorate over time and allow the pressurized Halon 1202 to escape into the atmosphere. A new material needs to be developed that will not deteriorate nor allow the pressurized Halon 1202 to escape.

PHASE I: Assess feasibility, compare various concepts, and perform tests to validate a particular concept for full evaluation. A prototype material may be developed and demonstrated in this phase.

PHASE II: Develop the new material and manufacture prototype o-rings and seals. Reliability, maintainability, evaluation of potential damage to aerospace materials, and cost-effectiveness of the developed technology shall be addressed/evaluated in this phase.

PHASE III DUAL USE APPLICATIONS: Private industry and other government agencies have both an aerospace and non-aerospace need for this material. This technology will be useful in the commercial sector for containing and controlling pressurized Halon 1202. Potential applications include commercial and private aircraft, ship/boat applications, or any other pressurized system using Halon 1202.

REFERENCES:
1) Technical Order 13F6-12-3, "Overhaul With Parts Breakdown Aircraft Fire Extinguisher,"
2) Clean Air Act
3) Clean Air Act Amendments of 1990
4) Georgia Rules for Air Quality

KEYWORDS: Gases, Seals, O-Rings, Halon 1202, Pressurized, Clean Air Act

AF99-290 TITLE: Java Based Automatic Test System and Test Program Set Environment

TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop a TPS using a platform independent test executive/resource controller and test development environment.

DESCRIPTION: The Air Force spends millions of dollars each year rehosting older TPSs to newer, more modernized ATSs. Rehosting of TPSs is inevitable and is becoming more frequent, since the average supportable life of newer ATSs is now less than 7 years. ATS technologies are changing at an exponential rate, making test equipment obsolete much quicker. One of the primary factors in TPS rehost costs is platform dependence. During the rehost process, this platform dependency often forces the AF/DoD to search out emulation techniques that provide a degree of TPS transferability but add additional maintenance complexity. With the advent of the JAVA based programming language, TPSs can now be written and developed in processor independent ways, elevating the need for translators. This will also allow TPSs to be migrated between different platforms, given that both systems have a similar instrument complement and interface connection. This idea of using JAVA in both the ATS test executive and resource controller within a TPS can yield significant cost savings, especially since the AF currently has no standardized software test platform.

PHASE I: Develop a JAVA-based ATS and runtime/platform independent TPS. This phase will include the development of a comprehensive JAVA ATS software architecture and a process for using JAVA in both ATS control and TPS development. The architecture and JAVA class structure for test must be adequately documented, to include as a minimum the architecture and test class object models, IDL or equivalent specifications for the JAVA objects, and explanatory text. Phase I should also include a demonstration of a simple JAVA-based ATS using the defined software technology and architecture to show the concepts of utilizing a TPS across similar test platforms.

PHASE II: Develop a full-up prototype which will include an ATS running JAVA based code and a medium complexity mixed signal TPS developed to prove the concept. JAVA based TPSs will also need to be benchmarked against other commercially available TPS development toolsets, comparing performance, maintainability, reusability and rehostability of the TPSs.

PHASE III DUAL USE APPLICATIONS: This project has the potential to revolutionize the commercial ATS market as we currently know it. The standardization of ATS and TPS software will be quickly embraced by the commercial airline industry. Successful demonstration of the prototype would serve as a springboard for other commercial developers to market similar products.

REFERENCES:
1) Longuemare Memo, dated 29 April 94, "DoD Policy for Automatic Test Systems" SECDEF Memorandum, dated 29 June 94, "Specifications and Standards - A New Way of Doing Business"
2) USD (A&T) Memorandum, dated 29 November 94, "Acquisition of Weapons Systems Electronics Using Open Systems Specifications and Standards"

KEYWORDS: JAVA, Software Reuse, Software Rehost, Test Program Sets, Automatic Test Systems

AF99-291 TITLE: A Five-Function PCMCIA/CardBUS Device for Diagnostic Testing

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop a five-function PCMCIA/CardBUS device to include wireless communication, Fortezza Security, Ethernet, IEEE-488, and MIL-STD-1553 capability.

DESCRIPTION: The Air Force has a growing need for a downsized test capability using commercial technology. To further exploit existing PCMCIA/CardBUS technology for diagnostic testing, the Air Force desires to create a five-function PCMCIA/CardBUS device that can operate in a subnotebook computer or palmtop based Portable Digital Assistant (PDA) type device. The combination of these functions will allow for 'wireless' communication with both the weapon system and its associated support equipment

(including Automatic Test Equipment (ATE)) in a secure environment. The Five-Function PCMCIA/CardBUS device will eliminate the need for bulky cables and nonstandard hardware interfaces at the organizational (flight-line) level. In addition, wireless communication will allow support equipment to communicate with the base LAN for other information including digital technical orders, test procedures, and aircraft Operation Flight Programs (OFPs). The user will be able to use Ethernet connectivity or utilize the built-in modem in most PDAs and subnotebooks for communication when out of wireless range. The incorporation of the MIL-STD-1553 and IEEE-488 protocols allows the device to access both aircraft Built-In-Test (BIT) and Automatic Test System (ATS) functions. Given the capability of commercial PDA devices which are based on Window CE platform, the compact PCMCIA diagnostic capability, combined with a hand held computer, provides wide range of connectivity options and a significant reduction in logistics footprint.

PHASE I: Phase I would consist of packaging research and the use of custom integrated circuits to meet the PCMCIA/CardBUS size requirement. Given the functional complexity of the device and its need for some ancillary cables, significant research would be required to ensure all the capability of the device could be brought out externally. In addition, power requirements will have to be investigated and identified to ensure a device could function within a reasonable period on batteries.

PHASE II: Development of a full-scale prototype that would include a demonstration of the device being utilized on a weapon system. The speed would need to be benchmarked against other PCMCIA/CardBUS devices and functions to ensure its performance.

PHASE III DUAL USE APPLICATIONS: Many commercial computer systems already incorporate dual PCMCIA/CardBUS slots, the potential to downsize current ATS test technology into laptops would revolutionize ATS organizational (flight-line) maintenance as we know it today. The device will also be quickly embraced by the commercial airline industry since the technology would be directly applicable. Successful demonstration of the prototype will serve as a springboard for other commercial developers to market similar products and enhance the density of PCMCIA/CardBUS devices.

REFERENCES: USD (A&T) Memorandum, dated 29 November 94, "Acquisition of Weapons Systems Electronics Using Open Systems Specifications and Standards"

KEYWORDS: PCMCIA, CardBUS, Wireless, Fortezza, Diagnostics, Automatic Test Systems

AF99-292 TITLE: Wireless Interface for Automatic Test Systems

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Incorporate wireless communication technology into a computer based ATS for data exchange.

DESCRIPTION: In military operations, a significant portion of the logistics footprint is the cabling that connects the automatic test equipment to the weapon system or component under test. Many times, modifications and upgrades to weapon systems will require a change in the physical interface between the ATS and the unit under test. A single test station may require many sets of cables to test all versions of a given weapon system. Although some effort has been made to specify standard interfaces, an innovative approach is to bypass the use of cables and implement wireless communication for data exchange. This technology could be applied to legacy systems via receiver and transmitter modules designed for the existing interfaces, and it could also be built into new development items.

PHASE I: The initial phase will evaluate existing wireless communication technology, and identify appropriate option(s). The type of information to be transmitted via the interface, i.e. test programs, diagnostic routines, self-test data, etc., will be identified. A specification for receiver and transmitter modules will be developed to create a wireless interface for the ATS. The research should also consider data integrity and security issues.

PHASE II: Develop a wireless interface prototype, utilizing commercial-off-the-shelf items wherever possible. This implementation will be targeted at a specific weapon system.

PHASE III DUAL USE APPLICATIONS: This project has a potential impact on all users of ATSs, both military and commercial. Successful demonstration of the prototype will allow proliferation within the DoD, and promote commercial competition to market similar products.

REFERENCES: SD (A&T) Memorandum, dated 29 November 94, "Acquisition of Weapons Systems Electronics Using Open Systems Specifications and Standards"

KEYWORDS: Receiver, Transmitter, Wireless Communication, Automatic Test Systems

AF99-293 TITLE: High Bandwidth Digital Rotating Interface (HI-DRI)

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop a digital interface capable of reliably passing multiple channels of very high bandwidth digital data across a continuously rotating axis.

DESCRIPTION: Current generation weapon system sensors are using detector arrays that generate digital image data at a rate of 100 to 250 megabits per second. These new sensor systems must be tested on rotating instrumentation platforms such as remotely operated turret systems or multi-axis flight tables. Current mechanisms for digital data transfer across these rotating interfaces generally utilize mechanical slip ring assemblies, which are limited to a data transfer rate of 10 to 50 megabits per second. A new capability must be developed to match the sensor data transfer rate across the rotating axes of these test platforms. This high bandwidth digital rotating interface must be able to handle multiple channels of high bit rate data and must have the design flexibility to be re-packaged into various mechanical shapes so that in can be utilized on a variety of test platforms. Anticipated requirements are:

a. Single channel data rates up to 250 megabits/sec
b. A minimum of 32 channels in a single assembly
c. Rotation rates up to 60 rpm, continuously
d. Adaptability to a variety of platforms including turret Systems, flight tables, etc.

PHASE I: Evaluate the feasibility of transmitting high bandwidth digital data across a rotating axis. Perform design approach trade-offs, define all hardware/software requirements, and prepare a validation test plan.

PHASE II: Design, develop and produce a prototype HI-DRI unit that meets the system requirements. Document performance capabilities, test results, and potential design variations to accommodate different mechanical shapes and test applications.

PHASE III DUAL USE APPLICATIONS: Transportation, emergency/medical, and manufacturing industries; any industry using remote sensing and robotics.

REFERENCES:

1) Ames, Gregory H. and Morency, Roger L., Passive, Multi-Channel Fiber Optic Rotary Joint Assembly, AD-D017 353, Dec 1994 PAT-APPL-151 396, PATENT 5 371 814
2) Ames, Gregory H., Method Providing Optimum Optical Trains Alignment in a Passive Multi-Channel Fiber Optic Rotary Joint, AD-D016 125, Dec 1993 PAT-APPL-956 328 PATENT 5 271076.

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: Digital, Data Transfer, High Bandwidth, Instrumentation, Rotary Interface

AF99-294 TITLE: Common Real-Time/Postmission Data System

TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop a Personal Computer (PC)- based capability to capture, process, display, record and play back synchronized data from multiple real-time test mission sources.

DESCRIPTION: The Air Force Test and Evaluation (T&E) community requires a new PC-based (Windows NT) capability to provide both synchronized real-time play and postmission playback of test mission data, including telemetry, video/audio, and Time Space Position Information (TSPI). The ability to gather, display, record, process and play back these multiple sources of data via a single integrated application will improve T&E analysis and reporting capabilities and reduce the cost and time associated with weapon system evaluation. More specifically, this application is envisioned to provide the following capabilities/ characteristics: (1) importing of the various data sources; (2) encoding of video signals; (3) generic statistical analysis features for data parameters; (4) 2D/3D/polar/stripchart plotting; (5) screen building capabilities for data visualization; (6) 3D flight visualization/control with range map overlays; (7) VCR type controls and a flexible setup capability with recall feature; and (8) automatic report generation with audio annotation capability that allows the operator to select or filter data to be included in a report. Key technical challenges for this effort include: synchronization of all data sources, and providing the ability to play back that captured real-time data with identical displays in postmission analysis.

PHASE I: Research appropriate technologies, define innovative ideas/approaches, perform trade-off analysis and determine hardware/ software requirements. Prepare validation test plan and document results.

PHASE II: Design, develop, produce and integrate prototype advanced multi-source test mission synchronized data playback system. Perform validation testing and document results.

PHASE III DUAL USE APPLICATIONS: Commercial applications include medical and commercial aviation use. For examples: (1) video of operations along with recordings of patients vital signs could be synchronized and then used to evaluate the operation or be used for training purposes; (2) cockpit video could be synchronized with recordings of cockpit data parameters to replay accidents and support training.

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KEYWORDS: TSPI Data, Telemetry, Synchronized Mission Playback of Video

AF99-295 TITLE: Munitions Lethality Computational Framework

TECHNOLOGY AREA: Modeling and Simulation (M&S)

OBJECTIVE: Develop a physics-based computational framework to support Air Force weapon systems testing, evaluation, and analysis.

DESCRIPTION: All Air Force weapon systems must be tested to assess their lethality and effectiveness against many classes of targets. Target classes generally include fixed structures (above and below ground), enemy air defense sites, and a variety of mobile ground and aerial targets. A wide array of Test and Evaluation (T&E) is required throughout the life cycle of a weapon system, including: research and measurement, digital and hardware-in-the-loop Modeling and Simulation (M&S), developmental and live fire validation testing, and operational and sustainment testing. The cost of T&E can be substantially reduced by decreasing the number of real world test events and increasing the use of M&S through the use of realistic physics-based analysis frameworks. This shift towards testing through M&S, however, is viable only when the computational framework is sophisticated enough to predict real world interaction and related phenomena. Existing models fall short in satisfying the required level of fidelity. It is believed that the key to achieving the desired computational realism is through iterative refinement of the physics-based model, based on input of actual test results and predictive comparisons. Innovative concepts are needed to develop the analytical and computational framework necessary to accurately model the physics involved in the highly dynamic interaction between weapon and target. Output results should include critical elements, such as specific target geometry versus time and resulting physical and functional damage caused by attacks on the various classes of targets. The most urgent need is to support evaluation of large and small conventional munitions with blast/fragmentation warheads, smaller smarter munitions with sophisticated terminal guidance, and the emerging class of directed energy weapons versus above ground and mobile targets. There is also significant opportunity for unification of the many different and competing computational architectures currently in use. This framework must include provisions for physics-based modeling of detonation, blast, fragmentation, incendiary, directed energy, airborne particulate dispersion, and other effects. The framework should accept test data for calibration of lethality models used to predict phenomenology, live fire, and operational test results. The framework must be consistent with the DoD High Level Architecture (HLA) requirements for digital modeling and simulation and it should be expandable to support an improved understanding of potential new lethal effects against all targets of military worth.

PHASE I: Define innovative ideas/concepts/techniques for developing a Munitions Lethality Computational Framework and evaluate candidate approaches. Develop and document hardware/ software requirements and verification/ validation test plans.

PHASE II:Design, develop and produce a prototype Munitions Lethality Computational Framework. Demonstrate/ document applicable models to predict phenomenology, developmental, Live Fire, and operational test results.

PHASE III DUAL USE APPLICATIONS: Commercial applications include analysis of space debris impact on commercial satellites and modeling and assessment of potential terrorist acts against commercial assets.

REFERENCES:

1) An Analysis Comparison Using the Vulnerability Analysis for Surface Targets (VAST) Computer Code and the Computation of Vulnerability Analysis Computation of Vulnerable Area and Repair Time (COVART III) Computer Code, ARL-MR-341, DTIC Ref AD-A321 736

2) Improved Fragmentation Algorithms for Debris Environments, DTIC Ref AD-A314 502

3) A guide to FASTGEN Target Geometric Modeling, JTCG/AS-92-SM-25, DTIC Ref AD-A273 171

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: Lethality, Effectiveness, Fragmentation, Vulnerability, Explosive-Blast, Physics-Based Models, Conventional Munitions, Target Geometric Modeling

AF99-297 TITLE: Object Oriented Damage Prediction and Target Vulnerability

TECHNOLOGY AREA: Modeling and Simulation (M&S)

OBJECTIVE: Develop a state-of-the-art methodology and model for predicting target damage from warhead detonation using Commercial Off-The-Shelf (COTS) object-oriented software applications.

DESCRIPTION: Current methods and models used for estimating target vulnerability to conventional munitions attack are no longer adequate for providing the accuracy and event visualization required today. Current damage assessment prediction models were designed and implemented using programming languages that are only capable of using simplistic point burst assumptions and expected value outcomes. Current models can not comply with the DoD regulation for all models, supporting major program decision milestones, to pass a vigorous Verification, Validation and Accreditation (VV&A). Innovative concepts are needed to increase the utility of damage prediction and vulnerability estimation models. Using state-of-the-art, object-oriented languages (like C++) and cutting edge graphical user interface design techniques, the process and procedures for accurately predicting target damage can be enhanced dramatically. New target damage products must be easily visualized and seamlessly integrated into higher level campaign and theater models. This new modeling capability, offering use of either Monte Carlo-based or deterministic prediction methodology, will support the model-test-model approach that is critical to today's streamlined, acquisition process. The new process must: (1) be Target Geometry Model (TGM) independent; (2) allow for more flexibility in various modes of operation (single burst point at a specified location, multiple burst points at specified locations, multiple burst points forming a specified grid, and multiple/ random burst points from a specified distribution); (3) calculate and output both vulnerable areas and probabilities of kill given a hit (Pk|h); (4) employ modern, object-oriented fault tree analysis methods; and (5) eliminate the need for "feeder models." The new modeling process must be modular for easy incorporation of new test information, new and novel kill mechanisms, and graphic output needs. Finally, this new process should run on both PC- based Windows applications or UNIX operating systems.

It is emphasized that this newly developed model must be capable of simultaneously supporting diverse analysis requirements of Analysis of Alternative studies, Congressionally mandated Live Fire Test and Evaluation (LFT&E), weapon trade and warhead optimization study for rapidly evolving smart munitions development programs. As such, the current legacy codes used by Eglinover that past three decades has provided absolutely critical milestone decision data for programs such as the JSOW/BLU-97, Sensor Fused Weapon (Baseline and P3I), GAU-8 gun, Maverick, LOCAAS and HARM through and including validation versus LFT&E field trial results. Generally, methodology developed by the JTCG/ME applies to inventory munitions and is not applicable to thisrapidly evolving state-of-the-art smart munitions development concepts and programs, many of which involve new and exotic kill mechanisms. This is particularly true of comparisions to LFT&E results where JMEM methods based on MAE and target vulnerable area are wholly inadequate to the analysis requirements.

PHASE I: Research current technologies, determine and document current model deficiencies, define innovative concepts/approaches, perform trade-off analysis to determine best value concept. Develop and document hardware/ software requirements and prepare VV&A test plan.

PHASE II: Design, develop and implement prototype vulnerability assessment model with applicable hardware and software. Verify and validate the system performance through realistic testing and demonstration; document system and results.

PHASE III DUAL USE APPLICATIONS: FBI and FEMA use predictive models of structural damage to buildings subjected to terrorist attack or natural disaster. Fault tree analysis methods of failure modes are applicable public conveyance systems, industrial machinery, and commercial space vehicles/ satellites.

REFERENCES:
1) Bruenning and Grove, Point Burst Damage Assessment Model (PDAM) Users Manual, AFATL Contract C08635-83-C-0010, Dec 1983
2)Bruenning, Fleming, and Becker, PDAM 95, System Description AFDTC Contract F08635-91-C-0002, Jan 1998 3) Improved Fragmentation Algorithms for Debris Environments, DNA TR-96-20, DTIC Ref AD-A314 502 4) A guide to FASTGEN Target Geometric Modeling, JTCG/AS-92-SM-25, DTIC Ref AD-A273 171.

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded

small businesses.

KEYWORDS: Model, Prediction, Assessment, Monte Carlo, Deterministic, Vulnerability, Probability of Kill, Target Geometry Models, Conventional Munitions

AF99-298 TITLE: Mission Level Modeling and Simulation Capability

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop a capability to transfer and utilize mission planning data to model and simulate mission level weapon system encounters in an existing Installed Systems Test Facility (ISTF).

DESCRIPTION: The Test and Evaluation (T&E) of current and future Air Force weapon systems require the capability of hardware-in-the-loop Modeling and Simulation (M&S) at the Mission ("many-on-many") level. Current M&S capabilities within the existing ISTF at Eglin AFB, Florida, is limited to the engagement (one-on-one) level. Innovative solutions are needed to extend these capabilities to accommodate mission level M&S. Mission level models must access the same mission data currently provided to operational aircraft and weapons systems through various mission planning tools, such as the current Air Force Mission Support System (AFMSS) or the future Joint Mission Planning System (JMPS). Data from these mission planning tools, such as multiple flight path scenarios, terrain data, environmental conditions, etc., must be integrated into the existing ISTF simulation models. The objective of this new capability would be to capture all appropriate mission planning data from the various data sources and transfer devices and to transfer and exercise that data in existing engagement simulations. The research should focus on the application to command, control and communications environments. Pertinent considerations include, but are not limited to, synchronization, correlation and registration, of hardware and software from differing planning tool architectures.

PHASE I: Research appropriate technologies, perform trade-off analysis, and define the hardware and software requirements needed to transfer and integrate mission planning data from multiple sources and planning tools into the existing engagement simulations. Document results and prepare validation test plan.

PHASE II:Design, develop, produce and integrate a prototype Mission Level M&S capability within the existing ISTF. Demonstrate and validate a mission level model using data from a mission planning system (such as AFMSS). Validate and document the results and the method of operation.

PHASE III DUAL USE APPLICATIONS: The commercial space and the advanced automotive industries will utilize M&S capability for mission planning. Examples include development of mission planning tools for reusable launch vehicles or deployment of a national automated highway system.

REFERENCES: Deis, Michael, PRIMES Users Manual, May 1998.

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: Command, Mission Level Model, Engagement Level Model, Mission Planning Tools, Modeling and Simulation, Installed Systems Test Facility, Control and Communications (C3)

AF99-299 TITLE: Off-board Targeting Data Link Simulation Capability

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop a system to simulate the data link functions required for various off-board targeting applications and integrate this system into an existing Installed Systems Test Facility (ISTF).

DESCRIPTION: Off-board targeting is the concept of passing digital target information from one weapon system platform to another through use of data links. For example, one aircraft might provide target identification and location information directly to another aircraft through a data link without pilot communication. Future aerial and ground weapons platforms will incorporate cooperative targeting and automatic vehicle-to-vehicle information exchange to maximize mission effectiveness by implementing a variety of data link functions. A need exists to be able to model and simulate the actual data link functions and the information transfer within an existing ISTF at Eglin AFB, Florida. The capabilities of the existing facility include target generation simulation. The objective of this topic is to replicate or simulate the data link functions between multiple platforms (i.e., aircraft, mobile ground

vehicles, ground stations, etc.) and to integrate this new capability into the existing ISTF capability. Pertinent considerations include, but, are not limited to: identification of all existing command, control and communications (C3) data links; accuracy requirements for off-board data exchange applications; and integration requirements for providing a common coordinate reference system for airborne, ground, and space sensor data link simulation algorithms.

PHASE I: Research applicable technologies, perform trade-off analysis, and define the hardware and software requirements needed to simulate realistic off-board targeting data links. Determine the integration requirements to incorporate the capability into the existing ISTF. Document results and prepare validation test plans.

PHASE II: Design, develop, produce and integrate a prototype system that simulates real world data link functions, using a common data link coordinate reference system, within the simulated environment of the existing ISTF. Validate and document the results and the method of operation.

PHASE III DUAL USE APPLICATION: The commercial aviation and the intelligent automotive industry will use cooperative data link systems. Examples are foul weather navigation for commercial aviation and coordinated control of vehicle braking on automated highway systems.

REFERENCES: Kirchner, Rick, Fincher, Ted, and Armogida, Frank, Rapid Targeting and Real-Time Response: The Critical Links for Effective Use of Combined Intelligence Products In Combat Operations, XB-NAWC-WPNS, AD-A318 888, Dec 1996.

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: Command, Data Links, Off-Board Targeting, Cooperative Systems, Coordinated Control, Control and Communications (C3), Installed Systems Test Facility

AF99-300 TITLE: Bit Rate Agile Onboard Telemetry Formatter

TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop onboard data cycle map (DCM) formatter that can generate DCMs of any bit rate.

DESCRIPTION: Frequency spectrum availability for use in telemetry is decreasing [1] and hardware to support efficient use of this spectrum needs to be developed. A significant waste of this spectrum is caused by onboard DCM formatters, which restrict the bit rates of the generated DCMs. A DCM formatter providing full control of bit rate would allow for the transmission of exactly what data are required. Further waste is incurred through word fill caused by the use of fixed word sizes in DCMs. Thus, the developed system should also support mixed word lengths. That is, different word lengths should be allowed within the same DCM. The developed formatter should be flexible and programmable enough to be used with various existing onboard instrumentation systems (e.g., AATIS, CAIS, etc.). That is, the formatter should not be limited to one proprietary instrumentation system. The formatter must be small and ruggedized in order to meet onboard requirements. Available format bit rates should exceed bit rates specified by existing systems and standards. Word lengths of 1 to 64 bits should be available. This project should not present a theoretical challenge. The emphasis here is on applying theory and on resolving the technical aspects of implementing a versatile piece of hardware. The formatter should provide technical agility and platform independence. It should be designed on open architecture and plug and play concepts.

PHASE I: Analyze feasibility of developing a bit rate agile airborne instrumentation controller/formatter, which can interoperate with existing airborne instrumentation systems. Develop preliminary designs for such systems. Provide a final report of analysis and recommendations.

PHASE II: Build and test a demonstration system. Validate bit rate agility, word length agility, and bandwidth savings in ground based and airborne tests at the Air Force Flight Test Center, Edwards AFB, California.

PHASE III DUAL USE APPLICATIONS: Any user of telemetry is a potential customer. The requirement for efficient use of telemetry bandwidth is being driven by both an increase in the amount of data to be transmitted and a decrease in spectrum availability. Further, the commercial uses of telemetry are expanding. The need for agile telemetry systems is just starting to be discussed and a company developing such a system has the potential of becoming a leader in an expanding market.

REFERENCES:
1) Timothy A. Chalfant, Erwin H. Straehley and Earl R. Switzer, "Advanced Ranged Telemetry (ARTM) Preparing for a New Generation of Telemetry," Proceedings of the International Telemetering Conference (ITC), Vol. XXXII, 1996 paper number 96-24-2
2) Charles H. Jones and Lee S. Gardner, "Complexity of PCM Formatting," Proceedings of the International Telemetering

Conference (ITC), Vol. XXXIII, 1997 paper number 97-10-5.

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: Bandwidth, Telemetry, Bit Rate Agility, Frequency Spectrum, Test Instrumentation

AF99-301 TITLE: Flutter Suppression System Test Techniques

TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop a safe and efficient approach for conducting flight test envelope expansion on aircraft that utilize a flutter suppression system to stabilize an aircraft that is inherently structural dynamically unstable within the aircraft's operational envelope.

DESCRIPTION: There is an ongoing effort to reduce the structural weight of aircraft in order to enhance performance characteristics. The weight reduction will likely result in airframes that are not as stiff, which will increase the chances of inherent structural dynamic instabilities. One method of improving aeroelastic stability characteristics is to utilize a flutter suppression system. Flutter suppression systems have already been demonstrated at the government laboratories and will undoubtedly be incorporated on future aircraft. An aircraft that utilizes an active flutter suppression system will have dramatically different instability characteristics than a conventional aircraft. Using traditional methods to flight test this type of aircraft will increase risk, and could be completely ineffective. Therefore it is necessary to rethink the way flutter flight testing should be done for aircraft with flutter suppression systems. The conditions that lead to a flutter suppression system being incapable of stabilizing the aircraft need to be identified. New criteria need to be produced to anticipate those conditions before instabilities occur. Visualizations techniques need to be developed so that the flight test engineer can easily identify potential instabilities and take appropriate action. A program needs to be produced that incorporates these new techniques into a single package that can easily be incorporated into the control room.

PHASE I: Study the conditions that lead to flutter suppression systems being incapable of stabilizing the aircraft and identify the indicators that instabilities are impending. Develop an efficient method to expand the flight envelope of an aircraft equipped with a flutter suppression system and go-no go knock it off criteria. Report all findings.

PHASE II:Develop a software program to execute the envelope expansion plan and demonstrate its ability to anticipate conditions where a flutter suppression system will be unable to stabilize the aircraft.

PHASE III DUAL USE APPLICATIONS: In time flutter suppression systems will also be incorporated into commercial aircraft and the same type of build up will be necessary. Flutter suppression systems are a small facet of the larger field of controls. This technology could be used to anticipate failures in other controls applications.

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KEYWORDS: Flutter, Controls, Aeroelastic, Active Damping, Flutter Suppression

AF99-302 TITLE: Instrumentation Network Architecture

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop high performance instrumentation network architecture.

DESCRIPTION: As test articles become more complex, their testing and data acquisition requirements are spiraling upward. These new data acquisition requirements span numerous areas such as performance, upgradeability, cost, and versatility. Merely upgrading these present systems is not a viable path to meet future requirements. A new approach that will allow the timely insertion of leading edge technology is crucial to meet ever increasing demands. To cost-effectively meet this need, an instrumentation network that is capable, versatile, and open is required. The architecture must support laboratory, cargo aircraft, fighter aircraft, helicopter, and modeling and simulation environments. The communication protocol must take into account data acquisition, unit programming, measurement processing and display, telemetry, and recording capabilities. In addition, the architecture must be flexible to allow real-time changes in both data acquisition and distribution. This includes integration of frequency spectrum efficient technologies developed to support the Advanced Range Telemetry (ARTM) program.

PHASE I: Research network architecture beyond current capability in terms of technical performance characteristics and implementation cost impact. Select and propose one or more specific methods for demonstration.

PHASE II: Build and test a demonstration system. Validate performance and characteristics in laboratory or ground based open-air-tests and support flight trials at the Air Force Flight Test Center, Edwards AFB, California.

PHASE III DUAL USE APPLICATIONS: The commercial application of this project would extend to commercial airliner testing, automotive testing, product manufacturing, and modeling and simulation.

REFERENCES:

1) "Range Telemetry Improvement & Modernization" by Tim Chalfant and Chuck Irving. Published in the 1997 International Telemetering Conference (ITC) proceedings, volume XXXIII. For more information, contact the ARTM Joint Program Office, Chuck Irving, (805) 275-4055, Edwards AFB, CA 93524-8300

2) "Smart Sensor Networked System" by Fernando Gen-Kuoing and Alex Karolys (Endevco). Published in the 1997 ITC proceedings, volume XXXIII 3) Telemetry Standards, IRIG Standard 106-96, May 1996, Secretariat, Range Commanders Council, U.S. Army White Sands Missile Range, New Mexico 88002-5110.

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KEYWORDS: Network, Data Telemetry, Data Processing, Instrumentation, Communication Protocol

AF99-305 TITLE: Parameter Identification of Short Takeoff and Vertical Landing (STOVL) Aerodynamic Characteristics during Hovering and Transition from/to Wing Borne

TECHNOLOGY AREA: Modeling and Simulation

OBJECTIVE: Extend parameter identification techniques to STOVL aircraft during hovering and transition from/to wing borne flight.

DESCRIPTION: Parameter estimation techniques have been used extensively to identify in-flight aerodynamics in support of numerous flight test programs with a high degree of success. Because of the importance of the aerodynamics regarding the flying qualities, it is important to determine the accuracy of the predicted aerodynamic model, and devise strategies for correcting it online. During hovering and transition from/to wing borne flight, the dynamics of STOVL aircraft and the corresponding aerodynamic models are highly non-linear, stochastic, and a strong function of height-above-ground and forward speed, which makes the parameter identification a difficult task. Successful application of parameter estimation techniques to this regime needs to be demonstrated.

There are several advantages to the AF in improving the accuracy of aerodynamic models from flight tests: 1) Necessary to understand aircraft flying qualities; 2) Necessary when flight control system deficiencies must be corrected; 3) Used to validate contractor prediction methods; 4) Used to reduce flight test risks through more accurate predictions of envelope expansion test points; 5) Necessary to increase the usefulness of the flight test simulator during the test program; 6) Necessary when tests are to be standardized to a selected aircraft configuration and flight condition; and 7) A properly validated model can reduce program risk by allowing more accurate predictions of operational effectiveness and suitability.

This technology has direct application to the Joint Strike Fighter (JSF). The JSF will be relying heavily on modeling and simulation during both the program definition and risk reduction, and the engineering, manufacturing, and development phases of the program. A properly validated model can reduce program risk by allowing efficient correction of deficiencies by avoiding the fly-fix-fly method.

PHASE I: Develop accurate model structure determination and aerodynamic parameter identification techniques for STOVL aircraft in operating in ground effect. Demonstrate the performance of the algorithm using 6 degree-of-freedom (DOF) simulations.

PHASE II: Develop, test and deliver software for complete identification of STOVL aircraft aerodynamics from flight test data.

PHASE III DUAL USE APPLICATIONS: Potential commercial applications of the work proposed in Phase II are: 1. Vibration suppression for military aircraft, helicopters, rotocraft, commercial aircraft, ships and submarines. 2. Ground vibration testing for aerospace and ground vehicles, including automobiles. 3. Vibration monitoring/diagnostics for mechanical equipment, off-shore drilling platforms, bridges and high-rise buildings. 4. Industrial process identification.

REFERENCES: Klein, Vladislav: Determination of Airplane Model Structure From Flight Data Using Splines and Stepwise Regression, NASA Technical Paper 2126, 1983.

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KEYWORDS: Flight Test, Spline Models, Aerodynamic Modeling, Stability and Control, Parameter Identification, Short Takeoff and Vertical Landing (STOVL)

AF99-306 TITLE: Spectrally Efficient Target Imaging (SETI)

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop an advanced capability that enhances video images in real-time to be able to define targets against backgrounds of varying contrast and varying weather conditions including clouds, wind, haze, airborne particulate, and fog.

DESCRIPTION: Aircraft and munitions tracking at the Air Force Flight Test Center (AFFTC), Edwards AFB, California, and at other Department of Defense (DoD) ranges is becoming increasingly challenging. As the population of the surrounding areas of DoD test ranges increases, more pollution is deposited in the air resulting in increased airborne particulate, haze, and other phenomenon that reduce visibility. In addition to the pollution, aircraft and munitions are moving at a higher velocity, optical turbulence caused by surface heating causes severe image degradation, clouds, wind, fog, and background clutter are present, and some of the targets are stealthy. There are commercial, off-the-shelf (COTS) solutions to this problem; however, they are cost prohibitive. Infrared cameras typically cost tens of thousands of dollars, and the cost of range-gated laser camera systems is even more. The goal of the AFFTC is to develop an inexpensive, remotely operated, capability using spectral imaging that enhances video images in real time to be able to define targets against backgrounds of varying contrast and varying weather conditions including clouds, wind, haze, airborne particulate, and fog. This capability has to be more affordable than the devices already mentioned.

PHASE I: Conduct a feasibility analysis and prepare a recommended system design. Submit a final report covering the analysis results and the system design.

PHASE II: Build a proof of concept system and demonstrate its operation at the (AFFTC). Submit a final report on results of the demonstration.

PHASE III DUAL USE APPLICATIONS : Satellite surveillance, Commercial Photography, Motion Picture Industry, Law Enforcement Surveillance

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: IR Cameras, Air Pollution, Spectral Imagers, Optical Tracking, Image Enhancement, Electronic Optical Tunable Filter

AF99-307 TITLE: Common Test Instrumentation Kit

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Develop a TIK capable of application on a wide range of weapon systems.

DESCRIPTION: Test Instrumentation Kits (TIKs) are installed in a large variety of weapon systems to collect, encode, and transmit vehicle test telemetry data. The current approach to design and testing of a TIK is to develop a unique TIK for each individual weapon system. Wide-ranging requirements for throughput, power, encryption, and physical space limitations available for the TIK have resulted in the TIK design being incorporated into the system design process resulting in long-term design cycles. Extensive design and qualification testing are required for each unique TIK using today's methods. This approach has resulted in separate TIKs for the JDAM (Joint Direct Attack Munitions), JASSM, AGM-65, MALD (Miniature Air Launched Decoy), AGM-130, and AGM-142 systems, with little or no interchangeability or inoperability.

This effort should provide the engineering, research, and development necessary to standardize a TIK suited for wide-ranging applications in future weapons systems (such as MALD and LOCAAS). The baseline design may offer several options to meet the widest possible range of test vehicles, considering retrofit of existing TIK designs as a possibility. The effort will perform

verification testing to measured or calculated extreme environmental conditions rather than the minimum necessary for a specific program. Innovative design and packaging is essential. Guidelines for telemetry transmitting, receiving, and signal processing requirements should be taken from IRIG-STANDARD-106-96, Telemetry Standards. System specifications, component specifications, drawings, and test procedures will be part of this effort.

PHASE I: Define hardware and software system requirements, research appropriate technologies for the best design baseline, and determine the potential life cycle (design, development, and logistics support) cost savings associated with the use of a standardized TIK on a new start program. Develop system specifications and verification test plans.

PHASE II:Design, develop and produce a limited number of flight worthy prototype TIKs. Validate the system through verification testing and document results.

PHASE III DUAL USE APPLICATIONS: Industries such as oil and mining, commercial aviation and transportation have potential uses for this standard, highly reliable communications package capable of performing many functions remotely.

REFERENCES: IRIG-STANDARD-106-96, Telemetry Standards

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KEYWORDS: TIK, Global Positioning Systems (GPS)

AF99-308 TITLE: Atom or Molecular Technology for Testing Electronic Circuits

TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop a hardware/software method to improve test and failure detection capability using atom or molecular technology for Air Force systems.

DESCRIPTION: Theoretical methods to verify hardware functionality and determine defective components have serious limitations. These limitations are very costly and have the adverse effect of equipment life-cycle reduction. New approaches for test and failure detection utilizing technologies at the atomic or molecular level must be created to meet the testing requirements of new equipment and systems throughout the complete development life cycle. Understanding of hardware functionality has progressed to an atomic or molecular level. Atom or molecular technology is the science of visualizing, analyzing, controlling, scanning, and applying technologies at the atomic or molecular level. Technologies for identifying chemical categories of observing and measuring molecules or organic polymers on a surface or substrate, or in three-dimensional space using a mechanical probe, electron beam, or laser, (etc.) is the primary objective of this topic. Detection of faulty circuits at this level of surveillance is the primary objective of atom or molecular technology. Atom or molecular technology surveillance in a software controlled stimulus/sensor enviroment is a key issue. If this type of technology can be exploited for test, it could save on repair and equipment costs. Technologies need to be explored which can perceive hardware integrity at the molecular or atomic level. Techniques to perform this type of testing are needed to lower costs and improve fault-detection. Atom technology is of inter- and trans-disciplinary nature, crossing over boundaries of existing technological categories, and constitutes a generic technology common to various industrial fields, such as new materials, electronics, biotechnology and chemistry. An extensive secondary effect may be expected from this important research field.

PHASE I: Conduct research and develop procedures for candidate atom or molecular technologies to test and diagnose failures in Air Force hardware. Document application criteria of this technology to current established processes.

PHASE II: Identify, develop, and prototype the most promising atom or molecular technologies, including the development of experimental applications to evaluate their effectiveness.

PHASE III DUAL USE APPLICATIONS: Successful results can be applied to improving test performance in numerous commercial and industrial test and process control applications, such as new materials, electronics, biotechnology and chemistry.

REFERENCES:

1. Atom Technology, Joint Research Center for Atom Technology (JRCAT), SAIT, extended abstract '96 JRCAT Symp0sium on Atom Technology pp 181-194.

2. Paper Abstract. 93-22. Ultimate Manipulation of Atoms and Molecules "A New Project" Kazunobu Tanaka (NAIR) The Japan Society of Applied Phvsics. 1993. http://www.jrcat.or.jp/rc/tana/tana-paper-abs.html

3. D31.109 Scanning Reflection Electron Microscopy Study of an Initial Stage of Layer-by-Layer Sputtering of Si(111) surface. H. Watanabe, M. Ichikawa (Joint Research Center for Atom Technology), POSTER session, March 18, 1996.

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4. DTIC AD-A221 303, OPTICAL SOCIETY OF AMERICA WASHINGTON DC, Proceedings of the Topical Meeting on the Microphysics of Surfaces, Beams, and Adsorbates (3rd) Held in Salt Lake City, Utah on 27 February-1 March 1989
5. DTIC, AD-A122 446, VARIAN ASSOCIATES INC, PALO ALTO, CA. MBE in MOS Technology Applied to Speed Increases in VHSICs.

KEYWORDS: Molecular, Atom Technology, Nano Algorithms, Neural Networks, Genetic Algorithms, Automatic Test Equipment

AF99-310 TITLE: High Speed Digital Timing Sets and Pattern Generator

TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop software to automatically create high-speed stimulus patterns and timing sets for LASAR.

DESCRIPTION: Conduct research to determine if it is possible to automatically develop high-speed timing sets, stimulus patterns and probe timing sets for LASAR on a personal computer platform. Applicable LASAR factors which the software might use are component primitives, circuit models, and I/O. Digital circuits are tested on Automatic Test Equipment using a LASAR generated software routine. Engineers develop the circuit model, stimulus patterns and timing sets, then LASAR processes this information into a test routine. The engineering task required to figure out the timing set and proper pattern routine for a complex digital unit could be prodigious. Many factors become critical and when the engineer is dealing with thousands of different signal variations and possibilities, mistakes can be made and problems can be compounded. When subtle timing problems exist within a timing set, the guided probe and fault dictionary routines can and will identify good parts as bad. Even-though, the go/nogo path might be stable, a diagnostic routine, which is used to detect defective parts, can miss changes in the node state logic when a trigger or input timing sequence is slightly inexact. The dynamic software package is needed to augment the engineer's skill and accomplish the proper fix to critical timing problems.

PHASE I: Develop a software approach that will demonstrate high-speed timing sets, stimulus patterns, and probe timing sets for LASAR models.

PHASE II:Develop an experimental software prototype of the approach(es) defined during Phase I.

PHASE III DUAL USE APPLICATIONS: Will provide resolution of major problems like retest-OK (RTOK), and could-not duplicate (CND) in aircraft equipment repair. Significantly improves LASAR test software development time. Significant commercial markets exist for this technology in industrial process control and medical process applications.

KEYWORDS: LASAR V6, Digital Circuit Testing, Automatic Test Equipment

AF99-312 TITLE: Automatic Rail Alignment Checker

TECHNOLOGY AREA: Modeling and Simulation

OBJECTIVE: Provide a fast, accurate and independent method for verifying vertical and horizontal alignment of rails.

DESCRIPTION: Determine the effectiveness of an automatic rail alignment checker to provide quick status of the rail without relying on Defense Mapping Agency (DMA) surveys. Alignment of the rails is maintained through precision measurements and continuous adjustment of both horizontal and vertical rail alignment fixtures. Currently, the data obtained from Track surveyors has to be converted into track coordinates and compared to the rail fiducial line to obtain realignment settings to apply to each rail fixture. This process has to be repeated several times to minimize the rail alignment error. The checker is conceived as a towed sled which can travel over the rail to be inspected at speeds greater than 5 ft/s and accurately measure the rail at each interval to ±0.01 inch in both the vertical and lateral directions. The sled must carry the appropriate sensors and processing systems to efficiently collect and reduce the measurement data into information that can quickly determine the position of the rail immediately prior to a high speed sled test.

PHASE I: Design specialized sensors capable of measuring the position of the rail and rail fixtures and integrate those sensors with supporting hardware and software for a self-contained sled which can be towed on the rail and provide vertical and horizontal deviations to the fiducial line along the rail. Due to the extreme accuracy requirements, various measurement technologies, such as laser interferometry, will have to be advanced to provide a final product that satisfies all requirements.

PHASE II:Fabricate and test the automatic rail alignment checker to determine its accuracy, to establish operating and calibration procedures, to determine suitability and reliability for this application, and to make improvements, as needed, to provide quick, accurate reports of rail status to Track personnel.

PHASE III DUAL USE APPLICATIONS: The capability to assess the vertical and horizontal position of rails with respect to an established line can be applied wherever high accuracy is required or where other methods of establishing position are unavailable. Applications include high-speed trains, rail-mounted cranes or structures, and automated factories where robotic devices move on rails.

KEYWORDS: Fiducial Line, Rail Alignment, Horizontal and Vertical Deviations

AF99-313 TITLE: On-Line Engine Structural Vibrometer for High Cycle Fatigue (HCF) Turbine

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop a non-intrusive vibration measurement system for internal components of turbine engines (rotating blades, stator vanes, etc.).

DESCRIPTION: The goal is to directly measure component displacement and/or strain/stress over the whole surface of the component. The measurement system to be developed must provide an incremental improvement and a more direct physical measurement relative to the existing non-intrusive technique, the Non-Intrusive Stress Measurements System (NSMS). The NSMS uses a light probe to detect the time-of-arrival of the blade tip and infers tip displacement based upon a model of where the blade tip should be versus where it is.

The proposed vibrometer system must be a small (i.e., ~0.5" diameter threaded sensor nose for engine case mount) and rugged apparatus with no Foreign Object Damage (FOD) potential for the turbine engine or test facility. No intrusion into the gas flow path and nothing that would affect the vibrational characteristics of the components under investigation will be allowed. Adverse environmental considerations include, but are not limited to, window contamination, vibration, and heat. The vibrometer system must detect rigid body motion and dynamic displacement from vibration. Complex engine geometry will require case access view from high incidence angles to completely scan the components of the inner engine stages (width controlled by stator rows between the rotating blade rows). Rotating blade view may be periodically blocked by other components. Penetration of the compressor case for access to the inner stages or other minimal internal component surface preparation may be allowed (i.e., mirrors by polishing). Rapid scanning for transients, to minimize aliasing of high frequency vibrational motion, will be required if a single snap-shot approach is not used. A single snap-shot of the whole blade is the preferred approach. High speed image/data analysis for on-line use is required.

Specific system requirements include operating temperature ranges of -60 to 350F (1st stage fan) and up to 2200F (turbine area), 12" X 6" maximum blade dimension (1st stage fan), 2" X 1" minimum blade dimension (final high pressure compressor (HPC) stage), and rotational rates up to 20,000 RPM. The captured blade view should provide a minimum resolution equivalent to 200x100 Pixels, with the 200 pixel resolution configurable for alignment with the longest dimension of the blade. Potential blade deflection ranges from 0.0005" (short stiff HPC) to 1.5" (long, wide fan) with a frequency range of 0 to 30KHz. Blade edges must be well defined such that displacement/modal patterns can easily be overlaid onto a blade outline for the given view. The final output should be blade displacements/mode shapes as a function of view that are also resolved to the component surface perpendicular direction. Imaging lasers shall not damage component material in any way.

PHASE I: A proof of concept demonstration of a candidate technique meeting the bulk of the above requirements and challenges shall be performed.

PHASE II: A prototype system is to be demonstrated for shaker table operation and on an operating turbine engine in one or more areas, i.e., fan, compressor and turbine.

PHASE III DUAL USE APPLICATIONS: The instrument to be developed will have commercial applications with the commercial aircraft turbine-engine manufacturing industry as well as with the power generation industry. It will be applicable to both conventional steam turbines and stationary gas turbines.

REFERENCES:
1) Srinivasan, A.V., "Flutter and Resonant Vibration Characteristics of Engine Blades," Transactions of the ASME, Journal of Engineering for Gas Turbines and Power," vol. 119, pg 742-775, October 1997

2) K. L. Nichol , M. D. Sensmeier, and T. F. Tibbals, "Development of the Structural Dynamic Response Analysis Capability," Proceedings of 3rd National HCF Conference, San Antonio, Tx, February 2-5, 1998

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KEYWORDS: Vibrometer, Test Facility, Turbine Engine, Blade deflection, High Pressure Compressor

AF99-314 TITLE: Temporally and Spatially Resolved Spectrograph for 15-300 keV X-Rays

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop an instrument to measure the x-ray dose and spectrum over a large surface area at the position of a test object with spatial and temporal resolution.

DESCRIPTION: Making high accuracy temporal measurements of both spectral and spatial resolution of a flash x-ray simulator radiation-output are extremely difficult. Current detectors sacrifice resolution, or do only spectral or spatial resolving of radiation output. There is a need to make these measurements simultaneously with a high degree of resolution. The DECADE quad x-ray simulator irradiates a test object with radiation produced by four separate diodes that combine over the entire test area. The effective dose, dose-rate, and spectral hardness of the radiation are thus a combination of those four diode's radiation time histories. An instrument to measure the effective radiation on a test object would be extremely useful. The initial radiation source (MBS) for this measurement would be on the order of a mcal/cm2, a 30-40 nsec pulsewidth, and an area of 100 cm2. The goal is to then scale up to the DECADE radiation source of 20 krad (Si), 40-50 nsec pulsewidth, and 2500 cm2 area. Specifics for such a detector are
(1) Spatial Resolution - less than 5 mm
(2) Temporal Resolution - less than or equal to 2 nsec
(3) Spectral Resolution - 10% energy differentiation
(4) Data from the detector would be acquired by 224 channels of modified Analytek digitizers are on site
(5) Initial operation area for the detector would be 100 square centimeters
(6) Final operation area for the detector would be 2500 square centimeters
Development of the detector would include a software package for unfolding spectral and spatial data as well as error analysis of the instrument and a sensitivity matrix of all channels. The instrument would be required to be radiation tolerant or provide for calibration before each use as well as allow for easy replacement of radiation damaged components.

PHASE I: A concept demonstration and evaluation of the proposed instrument on the MBS shall be performed.

PHASE II: Fabricate, test, and deliver to AEDC a full scale instrument for use on the DECADE radiation source.

PHASE III DUAL USE APPLICATIONS: The commercial applications would be in the medical imaging and radiation therapy fields where precise spatial knowledge of the x-ray dose is required. There is also interest in the high energy physics and accelerator community for spatial information of x-rays and other ionizing radiation. There may be uses in x-ray inspection of aircraft parts and in other x-ray inspection applications.

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1) T.Ohkoshi, "Fundamentalsof Optical Fiber," OHM, 1-17 (1977)
2) H. Murata, "Handbook of Optical Fibers and Cables," Marcel Dekker, Inc 1996
3) F. Kapron, D. Keck, and R. Maurer, "radiation losses in glass optical waveguides," Appl. Phys. Lett., 17:423-425, Nov 1970
4) J. Hecht, "Understanding Fiber Optics," Sams Publ. 1993.

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KEYWORDS: X-Rays, Ionizing Radation, Spatial Resolution, Spectral Resolution, Flash X-Rays Simulator

AF99-315 TITLE: Fiber Optics Technology Application to Combined Temperature and Stress Measurement

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop a miniaturized Instrumentation System using Fiber Optics Technology for combined measurement of strain and temperature in wind tunnel or turbine engine test applications.

DESCRIPTION: In a recent Symposia of the Instrument Society of America (ISA) a novel approach to the measurement of strain using Bragg and Long Period Gratings was reported. This technique has potential application to balance technologies; increased sensitivity in a compact integrated sting/balance structure appears possible. Reference 1 focuses on the use of Bragg gratings and Reference 2 focuses on the use of long period gratings and describes a technique using higher order wave attenuation bands to simultaneously solve for temperature and strain. The Bragg grating has significant temperature sensitivity. The temperature sensitivity of a long period grating can be worse if special design considerations are not incorporated. A technique to produce a doped fiber and attendant calibration methodology that can be used to simultaneously make temperature and strain measurements

of sufficient accuracy to be incorporated into a balance and measurement system is needed.

The balance system (balance, instrumentation, software, calibration technique) for the Wind Tunnel Application requires a one-piece sting-balance combination where the balance element is circular in cross-section and is an integral extension of the sting. Miniaturization is vital (diameter of less than an eighth of an inch with a working stress of 1/3 yield). Furthermore, accuracy of stress measurement to better than 1% is needed over the temperature range of 40 to 160 degrees f, and temperature resolution and accuracy better than 1 degree and 2 degrees f, respectively, is needed.

The measurement system for Engine Test Application, that will permit measurement of stress and temperature of turbine engine components during operation, requires the ability to measure stress and temperature with accuracy of better than 1%. These measurements will be made over a temperature range of 400 to 2300 degrees F. The limitations of utilizing doped fibers may preclude the application of fibers with doped gratings to this range of temperatures. In this event, other fiber-optics applications will be considered. The capability to make stress and temperature measurements on rotating elements such as turbine blades is desirable.

Wind Tunnel Application:

PHASE I: Demonstrate experimentally the ability to produce a fiber optic strain PHASE Ibalance with temperature compensation for use in adverse thermal environment.

PHASE II: Develop and deliver a 1/8-inch diameter integral sting-model balance that is fiber optic sensor based with measurement capability for forces and moments about three orthogonal axes.

Turbine Engine Test Application:

PHASE I: Experimentally demonstrate the ability to produce a fiber optic-based combined strain and temperature measurement in an adverse thermal environment

PHASE II: Develop and deliver a fiber optic sensor based sensor to measure strain and temperature within the turbine engine environment.

PHASE III DUAL USE APPLICATIONS: The commercial market for such a device is extensive. The ability to measure stress and temperature simultaneously has many applications in the aerospace community as well in other industries such as automotive and chemical processing.

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1) Fiber Optic Sensors For Structural Monitoring, Kersey, A.D., et. al, ISA, 1997, 0227-7576/97/747-756, Orlando, Fla., May 4-8, 1997

2) Grating Based Optical fiber Sensors for Machinery Monitoring, Nemarich, Christopher, et. al, ISA, 1997, 0227-7576/97/727-738, Orlando, Fla., May 4-8, 1997

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KEYWORDS: Fiber Optics, Bragg Grating, Balance System, Stress Management, Strain Measurement, Long Period Grating

AF99-318 TITLE: Digital High-Speed Imaging Technologies-Hypersonic Wind Tunnel Support

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop an imaging device capable of producing high resolution planar-images at rates of up to 1 million frames per second.

DESCRIPTION: Evaluation of the performance of new hypersonic wind tunnel technologies will require high-speed diagnostics to follow the high frequency effects associated with the fluctuations in these high-speed flows. A system capable of digitally imaging flows at MHz rates is needed. The device must have high sensitivity in both the ultraviolet and visible portion of the spectrum. The imaging device will be used in conjunction with various laser diagnostic approaches including Rayleigh scattering, laser-induced fluorescence, shadowgraphs, and Schlieren techniques. The desired apparatus should provide:

1. High energy laser pulses with a few tens of nanosecond pulse-width
2. MHz rep-rates.
3. A laser that operates in a burst mode with several milliseconds of pulses per burst.
4. A digital recording system/camera capable of producing high quality images that give spatial information on flow properties such as density and are capable of following shock wave and boundary layer fluctuations.

The laser and camera/recording system must be reasonable in size, simple to operate, and extremely reliable.

PHASE I: A concept demonstration of a controllable MHz rate laser and digital camera/recording system will be performed.

PHASE II: Manufacture, deliver to the Arnold Engineering Development Center (AEDC), and demonstrate a laser and digital camera/recording system in an AEDC test facility.

PHASE III DUAL USE APPLICATIONS: The commercial market for such a device is extensive. The device would have applications in all high-speed aircraft/missile test facilities. Private testing laboratories could use the device in dynamic failure analyses.

REFERENCES:

1) Lempert, W.R., Wu, P.F., and Miles, R.B., "Filtered Rayleigh scattering measurements using a MHz rate pulse-burst laser system," AIAA Paper 97-0500, 35th Aerospace Sciences Meeting, Reno, NV, Jan 6-9, 1997.
2) Lempert, W.R., et al, "Pulse-burst laser system for high-speed flow diagnostics," AIAA Paper 96-0179, 34th Aerospace Sciences Meeting, Reno, NV, Jan 15-18, 1996.

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: Resolution, Sensitivity, Planar-Images, Spatial Information, Digital High-Speed Imaging

AF99-319 TITLE: High Temperature Probe Blade Tip Clearance Measurement System

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop a sensor for measurement of blade tip clearances in operating turbine engines with the capability to measure absolute clearance of individual blades.

DESCRIPTION: Excessive clearance between rotating blade tips and the stationary case of gas turbine engines can seriously degrade engine efficiency and performance. Capacitance probe systems are used to measure the blade tip clearances in operating turbine engines, but improvements in these systems are required to meet future engine development and diagnostic needs. Shortcomings of present systems include: poor probe lifetime at typical operating temperatures of 1400 F to 3000 F, difficult to install because of cable size, stiffness and length restrictions, cannot measure absolute clearances, cannot measure when engine is stopped or running at low speed, poor performance on shrouded rotors, systems read only average clearance, but individual blade clearance information is needed to obtain rotor dynamics data.

PHASE I: A proof-of-principal demonstration, showing system response capable of measuring individual blade clearance, will be performed.

PHASE II:A prototype blade tip clearance system with response capable of measuring individual blade clearance in turbine engines at operating temperatures of 1400 F to 3000 F.

PHASE III DUAL USE APPLICATIONS: The commercial market for such a device is large. Availability of robust blade tip clearance probes and signal processing electronics would greatly assist development of active clearance control systems and engine conditioning monitoring systems for production engines. In addition to flight engines, the market for this technology also includes stationary turbine engines used for electric power generation.

REFERENCES:

1) Sheard A. G., "Blade By Blade Tip Clearance Measurement in Aero and Industrial Turbo Machinery," Instrument Society of America, ISA Paper 91-080, 1991
2) A.G. Sheard, "Capacitive Measurement Of Compressor and Turbine Blade Tip To Casing Running Clearance," American Society of Mechanical Engineers, ASME Document 96-GT-349, 1996

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: Blade Tip, Tip Clearance, Capacitance Probe, Gas Turbine Engines, Active Clearance Control

AF99-323 TITLE: IDEF3 Based Training

TECHNOLOGY AREA: Manpower, Personnel, and Training

OBJECTIVE: Continuous training improvement concurrent with continuous process improvement.

DESCRIPTION: One of the major challenges of continuous process improvement is the concurrent propagation of process change to the process personnel training material. Air Force's IDEF3 Process Description Capture Method is a very rich and robust method for capturing process knowledge, and used widely for process reengineering and improvement. Process descriptions in IDEF3 contain the basic knowledge needed by personnel to perform the process. However, the IDEF3 format and span of knowledge may not be needed by all process personnel. In addition, without training in the IDEF3 method, the IDEF3 format of process knowledge may not be used by the average process worker. The successful proposal shall develop a commercially viable extraction of the IDEF3 process knowledge that is selected and delivered in a format that trains and assists process workers in their duties.

PHASE I: Demonstrate extraction of IDEF3 method knowledge and presentation in two or more formats.

PHASE II: Complete the development of the Phase I demonstration into a robust commercial training delivery system which can vary the content of knowledge and the format of delivery as needed by process personnel.

PHASE III DUAL USE APPLICATIONS: This technology has immediate application in all businesses because all businesses have process change and all businesses need personnel trained and retrained. This technology will improve the accuracy and timeliness of training to organizational personnel.

REFERENCES:

1) Mayer, R. J., et al. (1992). IDEF3 Process Description Capture Method Report AL/HR/TP-1992-0057, ADA252 633, Wright-Patterson AFB, OH: AL/HRGA.

2) Mayer, R. J., et al. (1994, in press). Ontology Capture Method (IDEF5) AL/HR/TP-1994-0029, ADA288442, Wright-Patterson AFB, OH: AL/HRGA.

3) Mayer, R.J., et al. (1997). IDEF3 Process Description Capture Method Report; AL/HR-TP-1996-0030, ADA329 632. Wright-Patterson AFB, OH: AL/HRGA.

KEYWORDS: IDEF3, Modeling, Training, Knowlege Delivery

AF99-324 TITLE: Advanced Multi-function Integrated Target Subsystem (AMITS)

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop a reduced cost, integrated aerial target subsystem to perform command/ control, autopilot, tracking, inertial, scoring and digital bus interface functions.

DESCRIPTION: The Air Force uses remotely piloted vehicles (or drones) as targets to test the effectiveness of airborne weapons. These aerial targets, either full scale or sub-scale in size, are configured and instrumented to replicate real world enemy aircraft. Current target vehicles must employ multiple subsystems to accomplish the command/ control, autopilot, tracking, inertial, scoring and digital bus interface functions. This multiple subsystem approach is expensive and requires excessive volume, creating a need to carry external pods. The use of external pods changes the multi-spectral signature of the target, thereby degrading the capability to replicate the various aircraft threats. Additionally, the use of pods on small subscale aerial targets severely degrades flight performance. Innovative approaches (including miniaturization, functional consolidation, and new technology insertion) are required to reduce system costs and the volume used by current subsystems. These innovations should eliminate the need for external pods through internal vehicle integration. Many technical challenges need to be addressed, including: (1) the command/ control data link must support long distances, over the horizon, with very low latency secure duplex digital data transfer; (2) common Tri-Service microprocessor architecture to perform the large amount of onboard computations is under consideration; (3) software written for older processors needs to be integrated into the common architecture; (4) Global Positioning System (GPS) and GLONASS (Russian GPS) data processing capability must be integrated to provide accurate tracking even in the presence of intentional GPS jamming; (5) cooperative target and missile GPS scoring capability is needed that can provide precision tracking in the high speed and high "g" air combat terminal environment; (6) low cost, tightly coupled GPS/ inertial capabilities are needed to eliminate the need for gyros and altimeters; (7) low cost digital bus capability to reduce wiring bundles; and (8) commercial technology needs to be adapted into an environmentally stressful military test and training application to reduce cost.

PHASE I: Research appropriate technologies, define innovative concepts/ approaches and perform technical and cost trade-off analyses. Determine hardware/ software requirements and evaluate critical components. Document results and prepare validation test plan.

PHASE II:Perform integrated system functional evaluation. Design, develop, produce and integrate a prototype AMITS unit into an aerial target. Validate performance and document results.

PHASE III DUAL USE APPLICATIONS: Commercial applications include use in industries that involve robotics and remotely controlled vehicles, such as manufacturing and sophisticated toys.

REFERENCES:

1) Advanced Avionics Subsystem and Technology (AAST) Backplane Bus Protocol IC, DN100195, Sep 1993

2) Yoder, Thomas L., The Use of Iridium, a Commercial Telecommunications Satellite System, in Wartime, AD-A312 259, June 1996.

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: Command, Scoring, Autopilot, Aerial Targets, Multi-Processor, Integrated Electronics, GPS and Inertial Reference, Control and Communications

AF99-325 TITLE: Onboard Smart Sensors

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop sensors, which can interactively communicate with (existing and future) onboard instrumentation controllers.

DESCRIPTION: The time and effort necessary to track sensor inventory and calibration for onboard systems can be extensive. An alternative is to have sensors which, when queried, can respond with all the 'vital statistics' regarding their functionality - e.g., whether they are working, what their calibration information is, what their serial number is, or simply what they measure. This would allow an instrumentation system to know exactly what is available on a test vehicle which, in turn, would allow the coordination of the instrumentation setup and the ground station setup for a test to be significantly simplified. Additional desired capabilities include generation of simulated output and autocalibration (changing the calibration coefficients in real-time). This would allow full pretest checkout and dynamic error correction which, in turn, would decrease maintenance and increase quality. The IEEE P1451 committee is establishing a standard [1] for smart sensors but there are few companies fully engaged in developing such instrumentation. A successful smart sensor would not only meet P1451 standards but would also be able to be linked into existing instrumentation systems (e.g., AATIS, CAIS, etc.). Sensors must be small and ruggedized to meet onboard requirements. Part of the emphasis here is that sensors need to be not only smart, but also versatile enough to be integrated into many different systems. They need to be compatible with the emerging smart sensor networks but also need the transitional ability to work with existing systems. That is, the designs should apply open architecture and plug and play technologies.

PHASE I: Research and analyze designs of smart sensors which can be used across existing instrumentation systems as well as meet IEEE P1451 standards. Provide a final report of analysis and recommendations.

PHASE II: Build prototype sensors. Test prototypes in ground based and airborne tests at the Air Force Flight Test Center, Edwards AFB, California.

PHASE III DUAL USE APPLICATIONS: Smart sensors are the 'plug and play' devices of instrumentation systems. IEEE has a proven track record for establishing standards that are used industry wide. An approved version of the P1451 standard is expected to be released soon and should instigate a wave of development of smart sensors. Thus, there is strong potential for such devices to be marketable to almost any user of data acquisition systems.

REFERENCES:

1) "IEEE P1451.2 D2.01 IEEE Draft Standard for A Smart Transducer Interface for Sensors and Actuators - Transducer to Microprocessor Communication Protocols and Transducer Electronic Data Sheet (TEDS) Formats," Institute of Electrical and Electronics Engineers, August 1996

2) Lee H. Eccles, "A 'Smart Sensor' Bus for Data Acquisition," Proceedings of the International Telemetering Conference (ITC), Vol. XXXII, 1996 paper number 96-05-3.

3) Fernando Gen-Kuong and Alex Karolys, "Smart Sensor Network System," Proceedings of the International Telemetering Conference (ITC), Vol. XXXIII, 1997 paper number 97-03-1.

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded

small businesses.

KEYWORDS: Telemetry, IEEE P1451, Smart Sensor, Instrumentation, Data Acquisition

AF99-326 TITLE: Laser Tracker Location Detection Capability

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop a capability to detect the location of a targeting laser spot and its power within an existing Installed Systems Test Facility (ISTF).

DESCRIPTION: Many current and future weapon systems utilize laser targeting and tracking technologies. These weapon systems will be tested in an existing ISTF at Eglin AFB, Florida. The Air Force needs the ability to: (1) determine tracking sensor and laser line of sight accuracy requirements; (2) measure laser pulse codes; and (3) model atmospheric effects and simulate laser ranging for weapon systems that use different laser wavelengths and power. Additionally, facility vulnerability analysis is required to determine the effects of lasers with different wavelengths and power operating within the test chamber. System and personnel safety issues, such as laser power status and laser spot location, must be evaluated and capabilities developed to prevent hazardous conditions. Technical challenges include developing methods for tracking sensor and laser line of sight accuracy, replicating laser pulse coding techniques, and simulating atmospheric effects and laser ranging.

PHASE I: Research appropriate technologies, establish innovative concepts/approaches, perform trade-off analyses, and define hardware/ software/ safety/ and integration requirements for use in existing ISTF. Prepare validation test plan and document results.

PHASE II:Design, develop, produce and integrate a prototype system within the existing ISTF. Validate and document the results and the method of operation.

PHASE III DUAL USE APPLICATIONS: Commercial applications include laser range finders, automated tollbooth detectors, automated heavy equipment control and automated highway systems.

REFERENCES: Deis, Michael, PRIMES Users Manual, May 1998.

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: LANTERN, Laser Ranging, PRIMES Facility, Laser Targeting, Laser Detection

AF99-328 TITLE: Avionics Sensor-based System Interoperability with Knowledge-based System Applications

TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop technology for interoperable and cooperative knowledge-based systems in weapon system and support applications.

DESCRIPTION: Develop software to translate sensor information from automatic test equipment into a common data format whereby the sensor data can be transported to a personal computer platform for evaluation. Advances in two areas are creating opportunities for new and diverse methods for improving weapon system and support equipment effectiveness. Advances in multi-sensor fusion are providing new methods for combining and interpreting passive and active sensor information in areas ranging from non-cooperative target recognition to geological mineral assessment. Technologies used to process this information include neural networks, generic algorithms, wavelets, fractals and the like. Communication technology advancements are providing new and increased capabilities for easily sharing data and information amongst geographically distributed sites using satellites, wide area networks, and the Internet. These combined capabilities can pave the way for the development of new approaches and techniques for utilizing remote sensor information cooperatively amongst interoperable distributed systems to perform various support tasks. Software which formats sensor data into a common data format promotes remote interpretation of test and sensor signal data communicated through the Internet and other means.

PHASE I: Design a prototype application of sensor data interpretation and formatting to demonstrate their effectiveness for evaluation on a personal computer platform. Develop methods for combining into current Air Force support practices.

PHASE II: Develop prototype software and combine methods into existing Air Force support processes. Evaluate program

results for their utility and effectiveness in enhancing Air Force support capability.

PHASE III DUAL USE APPLICATIONS: Potential exists for the application of interoperable cooperative knowledge-based systems in the military, commercial and industrial sectors in process control, intelligence, geological survey, medicine, automobile, aircraft and numerous other sensor fusion applications. Additional opportunities exist in law enforcement, insurance, banking, and financial industries where large amounts of data needs to be examined at geographically distributed sites.

REFERENCES:
1. Kirkland, L.V., "ATE Enabling Technologies", AUTOTESTCON 94' Anaheim, California, 21-24 September, 1994.
2. IEEE P1391 - Standard for Software Interfaces for Knowledge-based System Interoperability in Sensor-based Processing Applications
3. NORTH ATLANTIC TREATY ORGANIZATION BRUSSELS (BELGIUM), Executive Summary of the Technical Report on Distributed Systems Modeling Emphasizing Object-Orientation. Defense Research Group Panel 11 on Information Processing Technology. Research Study Group1 on Distributed System Design Methodology, Jan 1994.

KEYWORDS: Sensor-Fusion, Neural Networks, Genetic Algorithms, Emerging Software Tech, Automatic Test Equipment

AF99-330 TITLE: Automatic Conversion of Conventional Tabled Aerodynamic Models

TECHNOLOGY AREA: Modeling and Simulation

OBJECTIVE: Develop a computer algorithm to automatically scan and convert aerodynamic table lookup models into spline models or another form suitable for use with modern nonlinear Parameter Identification (PID) methods and simulation.

DESCRIPTION: Modeling and simulation (M&S) is becoming a large force in flight testing. In order to apply the theoretical advantages of M&S, model updating is required. Modern nonlinear parameter and systems identification programs do not work well with conventional total force and moment coefficient, table lookup aerodynamic models. These models are used in simulations due to their computational simplicity and ability to use linear interpolation and extrapolation. Unfortunately, these models are difficult to directly update based on flight test results. Modern nonlinear parameter identification(ID) methods work well with polynomial equations used for describing the forces and moments. Unfortunately, these models do not necessarily work well in simulation. A methodology which uses a hybrid of the two above techniques has shown promise for both use in simulation, and nonlinear parameter ID methodologies, this is the 'spline model' technique. The nonlinear forces and moments are described as a series of polynomials over a range of independent variables. Another promising technique is using multivariable orthogonal functions to describe analytic representations of the nonlinear aerodynamics.

Current and most future aerodynamic simulation models are, and will be, of the old total coefficient table lookup type. Modifying these models to a form suitable for nonlinear PID from flight test data is time consuming and expensive. Conversely, modifying flight test results to fit these table type look-up models is also time consuming and expensive. The cost in time and manpower hampers and slows down the ability to update aerodynamic models based on flight test results. A computer algorithm which will automatically convert a conventional table lookup model to a spline model, or another form suitable for applications of nonlinear Parameter ID methods as well as direct simulation use is required. Without this ability, full use of M&S benefits in flight testing will not be realized.

PHASE I: Investigate suitable formats for aerodynamic models and select one which is easily updated from flight test data using PID methods and a conversion algorithm to translate between this form and the conventional form used in simulation.

PHASE II:Construct a prototype application and demonstrate it at the Air Force Flight Test Center, Edwards AFB, California. The demonstration application will be evaluated to determine how well it satisfies the AFFTC requirements.

PHASE III DUAL USE APPLICATIONS: This solution has wide application to dynamic system modeling. The ability to easily update aerodynamic models directly from flight test has application in both defense and commercial related fields. It is envisioned that the ability to directly update model parameters from experimental data can be applied to a wide range of fields including; engineering, physics, chemistry, biology, etc. The mathematics and techniques required will be applicable to the modeling and simulation of any dynamic system. Modeling and simulation use in science and engineering is exploding as computer technology expands. The results of this solution could be used by any military, government, or commercial organization which requires accurate, updated systems models based on actual systems test results.

REFERENCES:
Klein, Vladislav: Determination of Airplane Model Structure From Flight Data Using Splines and Stepwise Regression, NASA Technical Paper 2126, 1983.

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: Flight Test, Spline Models, Aerodynamic Modeling, Stability and Control, Parameter Identification

AF99-331 TITLE: Distributed Beam Steering Controller

TECHNOLOGY AREA: Electronics

OBJECTIVE: Demonstrate that completely independent small, low cost, flexibly programmed, general purpose controllers allow beam steering of wide-band, modular, extensible and scalar phased array antennas.

DESCRIPTION: Phased array antennas consist of multiple stationary antenna elements, which are fed coherently and use variable phase or time-delay control at each element to scan a beam to given angles in space. The primary reason for using arrays is to produce a directive beam that can be repositioned (scanned) electronically. Phased array antennas allow precise beam patterning. They are complicated assemblies of radiating and receiving elements, phase shift networks, control electronics and a powerful computer that computes the required phase shift and time delay, if needed, at each element. This information is passed to individual or group decoders which drive the phase shifter and time delay units. The computer has knowledge of the physical topology of the phased array elements and the available phase shifts and time delays. The frequency of interest is also known. The steering commands are in terms of phase shift and time delays but the actual computation depends solely on time differences. Thus the phase shift is actually a function of the frequency of interest. All of this is currently accommodated by the out-of-date beam steering computer. These functions could be accomplished in a highly cost/weight effective manner through the application of a high density single chip computer, phase shift driver, and time delay driver, that is small, modular and flexible. This computer would make the computations based on a knowledge of the geometry of the phased array and the frequency of interest.

PHASE I: 1) Design a high density single chip phase shift and time delay controller that implements classical steering algorithms. Ensure that the hardware design of the controller incorporates only that hardware needed to execute the functions used by the specifics of a steering algorithm. 2) Fabricate a breadboard of the controller and demonstrate functionality.

PHASE II: 1) Finalize controller design. 2) Fabricate a prototype controller(s) using commercial processes. 3) Demonstrate functionality of the prototype commercial controller in accord with mutually agreed-upon requirements.

PHASE III DUAL USE APPLICATIONS: Antennas that can electronically point their beam are applicable to all of the existing and emerging communications systems. Agile steerable beams allow more channels in a geographical area. Such uses are for cell phones, personal communication systems (PCS), wireless modems, point of sale terminals, pagers. A successful high density single chip computer and phase shift driver as described in this project would be in high demand for commercial communication systems.

REFERENCES:
1. Phased Array Antenna Handbook (Artech House Antenna Library) by Robert J. Mailloux. ISBM: 0890065020.
2. Practical Phased-Array Antenna Systems by Eli Brookner (Artech house Publication, August 1991) ISBN: 0890065632.

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
Submission of Proposals

DARPA's charter is to help maintain U.S. technological superiority over, and to prevent technological surprise by, its potential adversaries. Thus, the DARPA goal is to pursue as many highly imaginative and innovative research ideas and concepts with potential military and dual-use applicability as the budget and other factors will allow.

DARPA has identified technical topics to which small businesses may respond in the first fiscal year (FY) 99 solicitation (99.1). Please note that these topics are UNCLASSIFIED and only UNCLASSIFIED proposals will be entertained. These are the only topics for which proposals will be accepted at this time. A list of the topics currently eligible for proposal submission is included, followed by full topic descriptions. The topics originated from DARPA technical program managers.

Please note that **5 copies** of each proposal must be mailed or hand-carried; DARPA will **not** accept proposal submissions by electronic facsimile (fax). A checklist has been prepared to assist small business activities in responding to DARPA topics. Please use this checklist prior to mailing or hand-carrying your proposal(s) to DARPA. Do not include the checklist with your proposal.

It is expected that the majority of DARPA Phase I awards will be Firm Fixed Price contracts. Phase I proposals **shall not exceed $99,000**. DARPA Phase II proposals must be invited by the respective Phase I technical monitor. DARPA Phase II proposals must be structured as follows: the first 10-12 months (base effort) should be approximately $375,000; the second 10-12 months of incremental funding should also be approximately $375,000. The entire Phase II effort should not exceed $750,000. It is expected that a majority of the Phase II contracts will be Firm Fixed Price-Level of Effort or Cost Plus Fixed Fee.

The responsibility for implementing DARPA's SBIR Program rests with the Administration and Small Business Directorate (ASBD). The DARPA SBIR Program Manager is Ms. Connie Jacobs. DARPA invites the small business community to send proposals directly to DARPA at the following address:

DARPA/ASBD/SBIR
Attention: Ms. Connie Jacobs
3701 North Fairfax Drive
Arlington, VA 22203-1714

(703) 526-4170
Home Page http://www.darpa.mil

SBIR proposals will be processed by DARPA ASBD and distributed to the appropriate technical office for evaluation and action.

DARPA selects proposals for funding based on technical merit and the evaluation criteria contained in this solicitation document. DARPA gives evaluation criterion a., "The soundness and technical merit of the proposed approach and its incremental progress toward topic or subtopic solution" (refer to section 4.2 Evaluation Criteria - Phase I), twice the weight of the other two evaluation criteria. As funding is limited, DARPA reserves the right to select and fund only those proposals considered to be superior in overall technical quality and highly relevant to the DARPA mission. As a result, DARPA may fund more than one proposal in a specific topic area if the technical quality of the proposal(s) is deemed superior, or it may fund no proposals in a topic area. Each proposal submitted to DARPA must have a topic number and must be responsive to only one topic.

In order to ensure an expeditious award, cost proposals will be considered to be binding for a period of 180 days from the closing date of this solicitation. For contractual purposes, proposals submitted to DARPA should include a statement of work which does not contain proprietary information. Successful offerors will be expected to begin

work no later than 28 days after contract award. For planning purposes, the contract award process is normally completed within 45 to 60 days from issuance of the selection notification letter to Phase I offerors.

On a pilot basis, the DoD SBIR Program has implemented a streamlined Fast Track process for SBIR projects that attract matching cash from an outside investor for the Phase II SBIR effort, as well as for the interim effort between Phases I and II. Refer to Section 4.5 for Fast Track instructions. DARPA encourages Fast Track Applications between the 5th and 6th month of the Phase I effort. Technical dialogue with DARPA Program Managers is encouraged to ensure research continuity during the interim period and Phase II. If a Phase II contract is awarded under the Fast Track program, the amount of the interim funding will be deducted from the Phase II award amount. It is expected that interim funding will not exceed $40,000.

DARPA 1999 Phase I SBIR
Checklist

1) Proposal Format

   a. Cover Sheet - Appendix A (identify topic number) ______

   b. Project Summary - Appendix B ______

   c. Identification and Significance of Problem or Opportunity ______

   d. Phase I Technical Objectives ______

   e. Phase I Work Plan ______

   f. Related Work ______

   g. Relationship with Future Research and/or Development ______

   h. Commercialization Strategy ______

   i. Key Personnel, Resumes ______

   j. Facilities/Equipment ______

   k. Consultants ______

   l. Prior, Current, or Pending Support ______

   m. Cost Proposal (see Appendix C of this Solicitation) ______

   n. Company Commercialization Report - Appendix E ______

2) Bindings

   a. Staple proposals in upper left-hand corner. ______

   b. **Do not** use a cover. ______

   c. **Do not** use special bindings. ______

3) Page Limitation

   a. Total for each proposal is 24 pages inclusive of cost proposal and resumes. ______

   b. Beyond the 24 page limit do not send appendices, attachments and/or additional references. ______

   c. Company Commercialization Report (Appendix E) is not included in the page count. ______

4) Submission Requirement for Each Proposal

   a. Original proposal, including signed Appendices A and B ______

   b. Four photocopies of original proposal, including signed Appendices A, B and E. ______

INDEX OF DARPA FY99.1 TOPICS

DARPA SB991-025	Collision-Avoidance Sensors for Micro Air Vehicles
DARPA SB991-026	Rankine Bottoming Cycle for Military Diesel Engines
DARPA SB991-027	Wavefront Sensing for Closed-Loop Adaptive Optics in Extended Scenes
DARPA SB991-028	Airborne Free Air Turbulence Measurement Device
DARPA SB991-029	Actuator Technologies for Micro-Adaptive Flow Control
DARPA SB991-030	Feedback-Controlled Predistortion Linearizer for Microwave Power Amplifier
DARPA SB991-031	Shock-Tolerant Auxiliary Bearing for Magnetic-Bearing Suspensions

SUBJECT/WORD INDEX TO THE DARPA FY88.1 TOPICS

DARPA 99.1 TOPIC DESCRIPTIONS

DARPA SB991-001 TITLE: Fabrication Process Development for High-Performance Micro Inertial Measurement Units

KEY TECHNOLOGY AREA: Sensors

OBJECTIVE: Improve performance and environmental tolerance of Micro Inertial Measurement Units (IMUs) by eliminating performance barriers and theoretical limitations imposed by current surface micro-machining techniques.

DESCRIPTION: Extreme miniaturization of sensors such as (IMUs) has become possible with the development of micro-machining technologies. In addition to vastly reducing size and weight, unprecedented reductions in cost and power consumption have been achieved. Unfortunately, performance has been the trade-off. Sensor structures created from very thin films have low lateral sensitivity, and lack structural rigidity perpendicular to the substrate. Bulk micro-machining techniques provide promise, but may impede multi-axis measurement. In order to achieve the level of (IMU) performance necessary for the next generation of small missiles, hybrid micro-machining processes need to be developed. It is envisioned that a combination of techniques from bulk micro-machining, surface micro-machining, silicon-on-insulator (SOI), or other processes could be combined or altered to form a defined fabrication process optimized for the development of robust, high-performing, single-package (IMUs). The goal of this topic is to address process and fabrication issues that theoretically limit (IMU) performance goals of both components and the integrated inertial unit. Performance issues include those of sensing-rate performance, performance over temperature, performance under conditions of dynamic roll, high acceleration, high frequency shock, and vibration. Integration issues include compromises between package size, multiple axis sensing, electronics packaging, common use/function designing, bonding, cross talk, mechanical limits, etc. Innovative approaches that provide short-term implementation without limiting long-term advancement are sought.

PHASE I: Identify specific fabrication techniques that address the enhancement of one or more (IMU) performance issues. Quantify the advantages of your approach, and conduct proof-of-principle experiments to verify proposed techniques. Short-term performance goals for a bias of 30 (/hr, with a dynamic range of (2,000 (/sec , over a temperature range of 0(C to +50(C must be ascertained achievable. Additionally, approaches toward the expansion of these goals to 1 (/hr, with a dynamic range of (15,000(/sec , over a temperature range of -40(C to +75(C must be, at least, theoretically discerned.

PHASE II: Validate your process design by fabricating brass-board prototype(s) of a (IMU) or (IMU) components suitable for small missile applications, and with performance specifications at or exceeding those named above - teaming with government, industry, or academia foundries as necessary. Confirm performance through laboratory testing. Component-only demonstrations must be substantiated with judicious examination of integration issues.

PHASE III DUAL USE APPLICATIONS: Commercialization of both (IMU) technologies and the fabrication processes developed are expected. (IMU) marketes extend from numerous automotive and aeronautical applications to mining and oil-drilling applications to helicopter rotor and robotic camera stabilization applications. Potential market sales of small, low-cost units are astronomical. Additionally, innovative processing techniques developed under this effort could be applied to other MicroElectroMechanical System (MEMS) devices to improve performance and/or component longevity.

KEYWORDS: Micro Electro-Mechanical Systems (MEMS), Inertial Measurement, Micromaching

REFERENCES:

1. Juneau, T. N., et al., “Commercialization of Precision Inertial Sensors with Integrated Signal Conditioning,” Proceedings of Sensors Expo, 1998, San Jose, CA
2. Proceedings of the Eleventh Annual International Workshop on Micro Electro Mechanical Systems, IEEE Catalog Number 98CH36176, Heidelberg, Germany, 25-29 January 1998
3. Ayazi, F., and Najafi, K., “Design and Fabrication of a High-Performance Polysisicon Vibrating Ring Gyroscope,” Proceedings of the Eleventh IEEE/ASME International Workshop on MEMS ’98
4. Weinberg, M. et al., “Micromachining Inertial Instruments,” SPIE Proceedings, Vol. 2879
5. Proceedings of the Solid-State Sensor and actuator Workshop, TRF Catalog Number
96TRF-0001, Hilton Head Island, SC, 3-6 June 1996
6. Macomber, G. R., and Fernandes, M., "Inertial Guidance Engineering," Prentice-Hall, Englewood Cliffs, New Jersey, 1962
7. Wringley, W., Hollister, W. M., and Denhard, W. G., "Gyroscope Theory, Design, and Instrumentation," MIT Press, 1969

DARPA SB991-002 TITLE: Flexible, Thin Films with Low Sheet Resistance and High Transparency

KEY TECHNOLOGY AREA: Materials and Processes

OBJECTIVE: The objective of this task is to develop transparent, conducting electrodes for flexible displays.

DESCRIPTION: Soldiers in the field require lightweight displays which can be rolled up and stored in a small container. With the rapidly maturing light emitting polymer field, an inexpensive, flexible display can be realized if a compatible transparent conductor can be developed. The market for transparent conductors has been dominated by indium tin oxide (ITO) and related compounds for 40 years [Ref.1]. Although usage of ITO films is widespread, these semiconducting films have limitations that are hindering the development of new technologies. One limitation is the relatively high sheet resistance which limits the area for a single display panel to 30 cm x 30 cm. The high sheet resistance also limits the speed and efficiency of the display. The primary problem with ITO for flexible displays is that ITO is brittle and will crack under slight deformations. The goal of the project is to develop flexible thin films having sheet resistance's of ~1 ohm/sq. The wavelength band of the transmission window should correspond to the spectral sensitivity of the human eye and have a minimum transmittance of 70% from 500-600 nm. The film growth should not require excessive substrate temperatures and fabrication procedures should be compatible with standard thin film processing techniques. Fabrication costs of the flexible films should be comparable to ITO. The electrical properties of the film should not change substantially when flexed to a 2-inch radius of curvature.

PHASE I: Demonstrate the fundamental technologies required to produce flexible thin films with low sheet resistance and high transparency.

PHASE II: Demonstrate compatibility with processes and materials used in light emitting polymer devices. Perform reliability and lifetime measurements on the flexible films at current densities typically used in light emitting diodes.

PHASE III DUAL USE APPLICATIONS: Applications for flexible, highly conducting, transparent, thin films include displays that are portable, thin, and conformal. Other applications areas for transparent conductors are protective coatings, solar cells, heat reflectors, and anti-static surface layers.

KEYWORDS: Transparent Electrodes, Thin Films, Flexible Displays

REFERENCE: H.L. Hartnagel, A.L. Dawar, A.K. Jain, and C. Jagadish, "Semiconducting, Transparent, Thin Films," Institute of Physics Publishing, Bristol, U.K., 1995

DARPA SB991-003 TITLE: Detection of Underwater Buried Mines

KEY TECHNOLOGY AREA: Sensors

OBJECTIVE: Define and demonstrate a simple prototype acoustic system that can significantly reduce the error rate for detection and classification of underwater buried mines in littoral environments, despite the fact that the mines may have reflectivity that is comparable to the surrounding clutter. The system should potentially have a high area coverage rate (i.e., it should not depend upon close-up examination of every spot on the ocean bottom).

DESCRIPTION: The objective is defined in terms of technical needs and not in terms of identified technology. In fact, it is tempting to state that the problem is too difficult and that a reliable and general solution does not exist. Dolphins in the Bahamas, however, can reliably find small, low-sonar-cross-section fish (some of which have no swim bladders) that have buried themselves in the sandy bottom, both in relatively bare areas and in areas with vegetation. Detection can occur at a distance of several meters. We are interested in identifying and exploiting the methods that are employed by these and other animals (e.g., biomimetics) and increasing the area coverage rate beyond that exhibited by the animals. Interest exists in the development of (1) appropriate signal processing/imaging techniques and (2) suitable acoustic sources/detectors as required. Multiple awards are anticipated and collaboration among offerors might be advantageous for successful completion of the effort.

PHASE I: Development of a signal processing system (in software) and a feasibility demonstration on simulated or pre-existing data. Identify new methods for suitable acoustic power generation and detection, and develop configurations which maximize transducer and/or system performance. Initiate development of a commercialization plan.

PHASE II: Complete signal processing software development and acoustic source/receiver prototype fabrication and demonstrate combined software/source/receiver performance on data obtained under controlled conditions and from a littoral environment.

PHASE III DUAL-USE APPLICATIONS: Undersea exploration for oil/mineral deposits and salvage operations; detection of terrestrial nonmetallic gas lines.

KEYWORDS: Littoral Mines, Biomimetics, Underwater Acoustics

DARPA SB991-004 TITLE: Multi-Functional Materials and Structures

KEY TECHNOLOGY AREA: Materials, Materials Processing, and Structures

OBJECTIVE: Demonstrate the feasibility and synthesis of materials and structures having multifunctional capabilities. Materials and fabrication techniques conducive to rapid prototyping are encouraged.

DESCRIPTION: Research and development leading to the creation of multifunctional materials and structures which enable multiple and simultaneous functions (e.g., structural, electromagnetic, sensing, power generation, etc.) to be performed by a single material system. While there are many DoD systems and components that would benefit from such materials, efforts should address multi-functional materials for mesoscale devices for the individual soldier and small, autonomous systems. At this size range ("sugar cube to fist"), the use of multi-functional materials should provide a significant advantage in such attributes as affordability, weight, volume, power consumption and/or performance. Fabrication techniques conducive to rapid prototyping are encouraged due to the ability to quickly produce test structures with the appropriate form, fit, and function.

PHASE I: In detail, define the materials system, the application, and the approaches for the design and manufacture of multifunctional materials and/or structures. Perform preliminary experiments demonstrating the ability to create such materials / structures. Quantitative advantages of the use of multi-functional materials in the selected application must be presented.

PHASE II: Prototype the multi-functional material system and demonstrate its specific advantages in the chosen application. Approaches for manufacturing of the prototype must be commensurate with full-scale production. Cost models for full-scale production should be developed.

PHASE III DUAL USE APPLICATIONS: The benefits of using multi-functional materials will be pervasive for many commercial applications. This is especially true in areas where power, volume, weight and/or cost are critical. Applications for which this concept is expected to have especially high commercial pay-off include portable systems, robotics, automotive, and spacecraft.

KEYWORDS: Multi-Functional Materials, Materials Development, Robotics

DARPA SB991-005 TITLE: Use of Nanotubes in Tools for Lithography and Microfabrication

KEY TECHNOLOGY AREA: Electronics; Manufacturing Science and Technology (MS&T); Materials, Processes, and Structures

OBJECTIVE: Exploit properties of carbon nanotubes for use in tools for lithography, semiconductor and micromechanical (MEMS) device fabrication, and metrology.

DESCRIPTION: The structural and electrical properties of carbon nanotubes enable a variety of implementations in tools for fabricating microstructures in semiconductor and related technologies. Nanotubes are candidate replacements for sharp tips for use in tools such as scanning probe microscopy, atomic force microscopy, and field emitters of electrons and ions. These tools provide solutions to a range of problems in sensing, pattern writing, measurements, deposition, etching, etc. In-situ growth may minimize problems of handling and mounting of the tips, as well as providing enhanced characteristics for operation in the tool. Control and reliability offer challenges to successful integration into tools for microfabrication. End-use applications often require an exacting combination of positioning, sensing, actuation, and associated instrumentation.

PHASE I: Explore the requirements of one or more applications in the broad areas indicated above. The contractor should show evidence of a close working relationship between the nanotube expert and the equipment manufacturer that will allow identification of technical challenges of tool integration, as well as technical approaches that indicate a path to successful integration. Project specifications of tool to be built during Phase II.

PHASE II: Fabricate a prototype tool using the nanotube component, integrate into a test configuration, and characterize the system performance.

PHASE III DUAL USE APPLICATIONS: The development will provide potential solutions in a key area of microelectronics and micromechanical structure fabrication. As the semiconductor industry moves to smaller feature sizes for integrated circuits, the push for efficient production places stringent demands upon metrology, microscopy, and mask and wafer writing, inspection, and repair. The small nanotube tips will provide improved reliability and stability of these very sensitive systems. Other areas of applications include displays, quantum effect devices, and the myriad MEMS applications beyond conventional microelectronics.

KEYWORDS: Nanotubes, Carbon, Lithography, Microfabrication, Proximal Probes.

REFERENCE: Special Issue on Nanometer-scale Science and Technology, Proc. IEEE, No. 4, vol 85, April 1997.

DARPA SB991-006 TITLE: Low Cost, High Performance Lasers for RF Photonics Applications

KEY TECHNOLOGY AREA: Electronics; Sensors

OBJECTIVE: Promote the development of low cost to manufacture designs for lasers for use in photonic transport of analog Radio Frequency (RF) signals in communication, radar and other RF signal processing systems.

DESCRIPTION: The application of photonic (laser) technologies for the transport of RF signals is a well established application that places severe performance requirements on the lasers used in terms of Relative Intensity Noise (RIN), output power and RF modulation response. For low RF frequencies (0.1-5 Ghz) direct modulation is possible and desirable, while at higher frequencies external modulators may be required. Semiconductor laser diodes and diode pumped solid state lasers have been used for these applications but to achieve the required performance relatively high cost to manufacture designs have typically resulted in limiting the range of potential applications, particularly large arrays requiring many photonic links. This program seeks to support innovative approaches to low cost to manufacture laser module designs that can meet high performance RF-Photonic link requirements. Candidate technologies are expected to exploit recent advances in photonic device and heterogeneous material integration. Of particular interest are means to incorporate emerging low cost to manufacture vertical cavity surface emitting laser (VCSEL) array modules and advanced integrated Distributed Feedback Laser (DFB) laser designs to achieve relatively high power sources capable of either direct modulation with high slope-efficiency, or of pumping low RIN solid state laser modules. Approaches that make use of alternatives to intensity modulation or which integrate external modulator components with laser source are also of interest.

PHASE I: Develop proof of concept design, either through fabrication of prototype components or by detailed modeling of designs based on demonstrated performance of existing components.

PHASE II: Develop and demonstrate a fully functional prototype capable of demonstrating critical functionality, providing design documentation for a full scale implementation.

PHASE III DUAL USE APPLICATIONS: Potential applications for low cost to manufacture RF Photonic lasers include remoting of antennas for cellular and micro-cell radio systems for use in military and commercial applications, the distribution of cable TV signals, signal processing for phased array antenna beam forming, and probing of microwave and milli-meter wave monolithic integrated circuits.

KEYWORDS: Lasers, RF Photonics, Analog Optical Links, Optically Controlled Phase Array Radar

DARPA SB991-007 TITLE: Integrated Solutions for Packaging of High Power Electronics

KEY TECHNOLOGY AREA: Electronics

OBJECTIVE: Create new packaging technologies for high power switching electronic devices and circuits.

DESCRIPTION: Innovative packaging technologies are needed for integration of new classes of high-power solid-state electronic components, such as diodes and switches, with sensors and microelectronic control within a half or full bridge module and with currents in the 100-350A range and voltages in the 1200-1600V range. Furthermore, new classes of high power handling wide bandgap semiconductor electronics are emerging that may dissipate very high powers or have very high power densities (on order of 107 W/m2). These new devices and circuits are under development to meet the widespread military and commercial needs for switching devices and integrated circuits that can satisfy the very high-current and high-voltage requirements of power transmission and distribution systems, hybrid- and all-electric vehicles, more-electric aircraft, and other types of electrical equipment and machinery. The device junctions in certain wideband semiconductor materials may reach temperatures of 300-400øC where application of conventional assembly and packaging technologies is difficult. Innovations are needed for an integrated solution to packaging of high power modules, including aspects of advanced interconnection, packaging, and assembly of these components and modules, package substrate materials, interconnect metallizations, thermal mitigation approaches, die attach, and power management. All offerors should address relevant issues of transient and steady-state operating temperatures of the packaged module because it is of critical importance. Technical approaches that are self-contained and minimize needs for external sources of thermal mitigation are encouraged. As applicable, offerors should provide a cost-performance analysis of the proposed approach.

PHASE I: Perform fundamental experiments and computer simulations that confirm feasibility of the technology for high power packaging. Demonstrate thermal stability of packaging technology.

PHASE II: Develop cost-effective processes and materials for high power packaging. Demonstrate critical aspects of packaging technology for large-scale applications.

PHASE III DUAL USE APPLICATIONS: Commercial and military applications for packaged high power devices and circuits include, switching devices and integrated circuits for electrical power transmission and distribution systems, hybrid- and all-electric vehicles, more-electric aircraft, and other types of electrical equipment and machinery.

KEYWORDS: Packaging, Electronic Packaging, High Power Electronics

DARPA SB991-008 TITLE: Miniature, Ultra-Low Phase Noise Oscillators for High Performance Analog-to-Digital Converters (ADCs)

KEY TECHNOLOGY AREA: Command, Control and Communications (C3)

OBJECTIVE: To develop ultra-stable, low power oscillators for the ADCs to be used in future generations of digital receivers.

DESCRIPTION: The current generation of digital transceivers being developed requires at least one mixer. In order to combat jamming and interference, the front end of a receiver may require 100 dB of instantaneous dynamic range over 100 MHz of bandwidth to enable cancellation of these signals. The resulting mixers would require high power consumption, making them impractical for man portable systems. Additionally, synthesizers with required thermal phase noise of -180 dBc/Hz at microwave frequencies are not available. Current oscillator techniques for low phase noise applications are also too bulky for use in miniaturized receivers. It is well known that it is possible to use an ADC (sampled at GHz frequencies) to directly sample the Radio Frequency (RF) signal with the down conversion performed digitally, removing the limitations of analog down conversion circuitry. However, one of several major limitations on accomplishing the high dynamic range includes jitter levels approaching 1 femtosecond for ADC sampling clocks in the GHz range. Efforts should address ideas for developing ultra-low phase noise oscillators that can be miniaturized for use in digital receivers (e.g., in a Personal Computer Memory Card International Association (PCMCIA) format). For example, a 0.2" x 0.5" x 0.5" oscillator (at 6 GHz) with a thermal floor of -170 dBc/Hz and 1/f^n corner frequencies less than 100 kHz (10 kHz preferably) could provide the characteristics needed for a transportable UHF and possibly L-band direct sampling digital receiver.

PHASE I: In detail, define the physical principle that will lead to the development of the ultra-low phase noise oscillator and quantify the expected benefit.

PHASE II: Develop a breadboard system to test the physical principle established in Phase I.

PHASE III DUAL USE APPLICATIONS: The development of ultra-low phase noise oscillators will greatly enhance performance capabilities of ADCs and the systems into which they are inserted (such as digital transceivers). The true all digital transceiver will inherit all of the benefits of Moore's law as digital technology progresses into the 21st century. Potential applications include software programmable radios (e.g., personal communication services [PCS]), enhanced communication payloads for Unmanned Air Vehicles (UAVs), and multi-mode receivers for military aircraft (such as F-15).

KEYWORDS: Low Phase Noise Oscillator, Analog-to-Digital Converter, ADC, Low Jitter, Stable Clock

DARPA SB991-09 TITLE: Streaming Multi-Sensor/Multimedia Software Viewers for the Warfighter

KEY TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop algorithms, software, and special hardware (if needed) to allow a tactical warfighter to view integrated streams of multimedia and multi-sensor data, such as video, Synthetic Aperture Radar (SAR), Moving Target Indication (MTI), Tactical Digital Information Link (TADIL) reports, Signal Intelligence (SIGINT) reports, Electro-Optical Infrared (EO/IR) imagery, 3-D terrain and feature data, and situation awareness overlays. The warfighter should be able to tailor the quality, quantity, and specific content of a multimedia stream to fit his individual mission needs, priorities and bandwidth available. This "viewer application" should interact with multimedia servers and underlying network mechanisms to adapt quality and content to available communications resources and characteristics. To achieve low life-cycle costs and interoperability for coalition operations, maximum use should be made of international commercial standards and products, developing new technology only where necessary to incorporate military specific formats, data types, communications protocols, or viewing requirements. The viewer should operate in a range of communication venues from broadband fiber to low-bandwidth wireless tactical radios. The

viewer should be able to support a variety of military operations from sensor-to-shooter applications in conventional warfare to surveillance and monitoring for force protection and peace-keeping operations.

DESCRIPTION: The warfighter of 2010 will have access to an emerging set of sensor, intelligence, and command and control data that is "streamed" down a network from its source to a warfighter's workstation, which maybe mobile or even worn like clothing. This data will include continuous streams of multimedia information (for example, video, computer graphics, images, audio, structured computer data, text) and multi-sensor data (for example, EO/IR video and images, SAR strip maps, slices of 3-D site and terrain models, and continuous SIGINT and MTIs). The warfighter will need to select portions of this information and combine it into a view that is directly related to his specific mission and function. The quality, quantity, and content of the viewed information must adapt to the available network and communications resources and match the warfighter's priorities. To be affordable, integrated multimedia and multi-sensor viewing applications need to be built around commercial standards and products using commodity computing equipment and displays, for example, a pop up viewer activated from a World Wide Web browser. For coalition operations, it is especially important that software viewers fit into commonly available information frameworks and international standards that are available to foreign nations, for example those of the Multi Media and Hypermedia Experts Group (MHEG) and the Moving Pictures Experts Group (MPEG). While emerging commercial products will answer much of the warfighter's needs, special military data formats, communications environments, and information needs will require some customization, translation, and extensions of commercial solutions. Efforts of interest include identifying future commercial products conforming to emerging international meta data and streaming multimedia standards, identifying unique Department of Defense (DoD) requirements and algorithmic modifications of commercial products needed for military applications, and demonstrations of streaming multimedia and multi-sensor viewers using existing military networks and radios. The commercial niche in viewers is to support single products across the Internet. While the viewers support MPEG and the Joint Photographics Expert Group (JPEG) standards and view a product in isolation and would be useful in the military, the military desires that all the information be placed onto one scene, thus integrated for decision making. This integration is the key for DOD. The DOD niche is a combination of applying real-time reconnaissance feeds that in many cases have mission/life critical implications. The viewer should be of the commercial nature but the product that is presented into the viewer should be integrated for the warfighter. Thus an MPEG video stream from a Unmanned Aerial Vehicle (UAV) could be viewed on a Joint Mapping Tool Kit (JMTK) map product coupled with imagery of the same area. Commercial viewers as the primary means would enable easy scaling across services and coalition forces. The integrated approach to handle multiple type streams and products within the viewer would allow tailoring with an applications such as a US Army command post that has systems such as Maneuver Control (MCS), Advanced Field Artillery Tactical Data System (AFATDS), etc. Each application within a viewer could have UAV, 3-D Virtual Reality modeling Language (VRML), and MTI tracks, OTH Gold Tracks, etc., as needed is the DoD product desired.

PHASE I: Develop an approach for viewing integrated multi-sensor, multimedia streams over tactical networks. Explain how the approach supports tailored, bandwidth-adaptive viewing. Explain how the proposed capability builds on standards-based commercial technology, defining any extensions or modifications of commercial approaches and products required for military operation. Select one or more military applications for analysis and quantify the expected operational benefits. The viewer should be a universally available viewer so that it can be populated throughout the Services, integration is open to multiple products that are streamed or archived with usual meta data information. The integration architecture is open for new products. Viewer must provide the warfighter the selectivity to adopt views based on viewing needs, computing infrastructure and communications infrastructure.

PHASE II: Develop a streaming multi-sensor, multimedia viewer for military applications and data sources using commercial components and international standards. Demonstrate its effectiveness in a military scenario. Deliver documentation of the results and an analysis of the potential impact on military operations. Define any required extensions to international standards for military applications.

PHASE III DUAL USE APPLICATIONS: Viewers for streaming multimedia are emerging as a major growth area for Internet electronic business and entertainment. Integration of direct multi-sensor feeds into powerful viewer applications will let the user control the content and format of his display and adapt quality and content to available bandwidth and network characteristics. Such a viewer will find ready commercial markets in distance learning, distributed interactive entertainment, electronic shopping, and security and monitoring. Commercial technology in turn will provide cost-effective commercial products supporting a new generation of multi-sensor situation awareness and sensor-to-shooter integration for law enforcement as well as new approaches to monitoring and surveillance for combating asymmetric threats.

KEYWORDS: Video, Protocols, Multi-Media, Software, Data Transmission, Tactical Digital Information Link, TADIL

DARPA SB991-010 TITLE: Model-Based Infrared and Synthetic Aperture Radar Fusion for Object Level Change Detection

KEY TECHNOLOGY AREA: Sensors; Computing and Software

OBJECTIVE: Develop model-based infrared and synthetic aperture radar (SAR) fusion algorithms that demonstrate an order-of-magnitude improvement in false alarm performance over existing single sensor object level change detection algorithms.

DESCRIPTION: Object level change detection (OLCD) algorithms extract object feature information over time from repeated sensor observations. The resulting image features are combined and stored in a database to yield a persistent baseline for detecting object level image changes. OLCD provides increased false alarm immunity by eliminating false alarms that match previously detected false alarms stored in the database. Because state-of-the-art OLCD algorithms are "view centered," their performance can be significantly degraded by the unexpected appearance of false changes caused by, among other things, variations in sensor collection geometry, solar illumination angles, poorly calibrated sensors, and object masking effects. Additionally, state-of-the-art OLCD approaches typically exploit single sensor phenomena, rather than combine cross-phenomenology multi-sensor change cues to confirm or deny change. The purpose of this research is to achieve an order-of-magnitude improvement in false alarm performance by developing algorithms that predict multi-sensor effects caused by apparent object level change, and fuse multi-sensor evidence to eliminate nuisance changes associated with these effects. The government will provide a multi-sensor data set for developing and evaluating models and algorithms. The data set will contain large quantities of spatially and temporally coincident infrared and SAR images collected during a 30-day period in early summer 1998 over a 4km x 6km Eglin Air Force Base test range C-72. Test data will be sequestered from this data set, and will be used by the government to produce statistically significant receiver operating curves to assess change detection performance.

PHASE I: Design and predict the performance of a model-based multi-sensor OLCD algorithm that eliminates apparent changes caused by man-made objects as a function of variations in sensor collection geometry and solar illumination angles. Man-made objects include military vehicles, facilities, line-of-communication towers, hangers, runway control towers, maintenance trailers, and fences. The algorithm should exploit phenomenology models to predict illumination and collection geometry effects on object and background signatures, and fuse SAR and infrared data to confirm or deny apparent changes. Algorithm performance should be predicted under a range of operating conditions using experimental and theoretical methods.

PHASE II: Develop, fully evaluate, and demonstrate a prototype of the algorithm designed in Phase I. If required, the government will provide 3D geometric models and prediction software for a limited set of man-made objects contained in the government furnished data set. Evaluation procedures will include a methodology for truthing real and apparent changes, as well as counting and scoring man-made object change detection and false changes. Deliver an object-oriented software implementation of the algorithm that can be demonstrated in the laboratory on a stand-alone basis, or incorporated in other DARPA technology products or systems as recommended by the proposer.

PHASE III DUAL USE APPLICATIONS: Dual use applications include any process requiring correlation of information from disparate sources for the purpose of detecting changes in natural and man-made objects in a low false alarm environment. Potential application areas include those requiring immediate determination of situation awareness such as transportation, environmental or natural disaster monitoring, medical emergencies, dynamic business operations, and complex manufacturing or chemical processes involving multiple sources of instrumentation and observation. Deliver a pre-production, stand-alone configuration that supports the most promising commercial application.

KEYWORDS: Change Detection, Automatic Target Recognition, Sensor Fusion, Site Modeling

DARPA SB991-011 TITLE: Structures for Complex Adaptive Systems (Fractal Architectures)

KEY TECHNOLOGY AREA: Command, Control and Communications (C3), Computing and Software

OBJECTIVE: Research and development leading to specifying, designing, implementing, describing, and adapting distributed software systems based on a fractal architecture approach for use in managing complex activities.

DESCRIPTION: Adaptation of a process might include removing system elements or rerouting message paths to support tighter feedback control loops. Approaches that focus on the definition of functional, tailorable components that can be composed in a fractal manner in order to achieve system dynamics objectives. It is expected that the components would operate at different hierarchical levels and different levels of granularity while sharing the same composable architecture. The system should exhibit similar characteristics at all levels without excessive overhead. Systems under dynamic operational stress, primarily dynamic process and workflow management and command and control are of particular interest. Efforts of interest include:

PHASE I: In detail, define the system architecture and design approach. Outline the system design, description, and adaptation approach. Describe how adaptation would occur and characterize performance issues for systems of different scales. Emphasis should be on exploiting the fractal nature of the architecture for unprecedented adaptive and dynamic charateristics.

PHASE II: Develop an initial implementation of the adaptive distributed fractal software systems and demonstrate them on a significant example of a dynamic software system. Complete documentation of test cases and results must be delivered. Emphasis should be on demonstrating the power of a fractal architecture approach and its use in dynamic environments.

PHASE III DUAL USE APPLICATIONS: The development of adaptive fractal systems will lead to new commercial markets for developers of complex systems dealing with dispersed entities in a highly dynamic environment. The potential of a fractal design to address the composability and adaptability of systems for highly dynamic environments could be a significant breakthrough for complex systems. "On-the-fly" re-design of complex systems will greatly enhance the utility of both commercial and military applications.

KEYWORDS: Systems Technology, Adaptive Workflow Management, Adaptive Software, System Design

DARPA SB991-012 TITLE: Information Warfare Simulation Architecture

KEY TECHNOLOGY AREA: Modeling and Simulation

OBJECTIVE: Development of federation architectures that supports the incorporation of Information Warfare (IW) in simulations.

DESCRIPTION: Research and development leading to implementation architectures in which highly classified IW techniques can be properly represented in simulation exercises while remaining insulated from other simulations enabling them to run at lower classification levels. Based upon the general, widely known methods used in IW, this effort must define the interactions required for proper representation of IW in simulations. It must account for the results of IW to properly affect the battlespace and for other actions within the battlespace to affect the operation of IW systems. Considering the various interactions, options for federation topographies must be explored. The capabilities and limitations of such topographies and conditions for their employment must be identified. The architectures developed must be shown to accommodate all identified required interactions.

PHASE I: Identify the interactions required between IW federates and simulations representing the rest of the battlespace. Identify potential architectures which accommodate these interactions and address classification difference between federates.

PHASE II: Develop an instance of one or more of the architectures. Demonstrate performance with conceptual IW models and a DoD simulation system that explicitly addresses the movement of battlespace information. Report on key metrics of the architectures' performance and the requirements to implement it with models of actual IW capabilities.

PHASE III DUAL USE APPLICATIONS: The commercial sector is more reliant than ever on information technology and significant infrastructures have been created to support this reliance. Along with this increased reliance, however, comes increased vulnerability. More and more, corporate espionage is targeting information systems. The architecture developed under this effort can be used to support vulnerability analyses of any corporate or commercial information network. Such analyses will provide industry the information they need to thoroughly understand their exposure or design additional safeguards.

KEYWORDS: Information Warfare, Network Security, Modeling and Simulation

DARPA SB991-013 TITLE: All Optical Fiber Optic Backbone for Advanced Data Networks

KEY TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Produce a high-speed fiber optic backbone structure that supports the transmission of multiple data protocols between multiple network stations.

DESCRIPTION: Next generation data networks for avionics, ships and other highly integrated multi-sensor platforms will require significant upgrades in data transport capacity, reconfigurability, survivability, etc. Current networks can neither support multiple protocols, nor can they easily be upgraded to new protocols. The current architecture requires multiple parallel wires or fibers to transport data between two stations; for the case of multiple stations (>2), electrical regeneration or electronic hubs are required. The Department of Defense (DoD) has a need for bi-directional redundant high speed (Gb / s) networks that can

support multiple protocols, topologies and security levels by providing each of these functions with its own dedicated channel. The goal is to produce a high-speed fiber optic backbone structure that supports the transmission of multiple data protocols between multiple network stations. These stations are "universal workstations" whereby all data in the system is available to all stations without the need for each station to request the data. The approach facilitates the rapid reconfiguration of networks without the need for restructuring the network protocols or topologies.

PHASE I: Validate the concept of an n-station network transmitting m signals simultaneously with different protocols such as Asynchronous Transfer Mode (ATM), Ethernet, and data formats. Demonstrate in the laboratory a minimum system with three nodes and two signals.

PHASE II: Demonstrate and evaluate n (n>20) stations network transmitting m (m>10) signals simultaneously. Incorporate turnable fiber optic sources and tunable fiber optic filters to demonstrate network reconfigurability.

PHASE III DUAL USE APPLICATIONS: PHASE III DUAL USE APPLICATIONS: Develop a low cost network with commercial, off-the-shelf components for DoD and commercial applications. The application of multi-signal optical backbone will enable new means to provide integrated control and support of large integrated commercial platforms; such as ships, commercial airliners, and automobiles, and integrated manufacturing equipment. This technology can potentially replace hundreds of wire or fiber bundles which make up a large part of the touch labor in the manufacturing process of the increasingly complex and computer controlled systems in transportation and manufacturing.

KEYWORDS: Fiber Optics, Networking, Avionics, Communications, Transport Protocols

DARPA SB991-014 TITLE: Smarter Sensors

KEY TECHNOLOGY AREA: Computing and Software; Sensors, 6.2 Exploratory Development

OBJECTIVE: Design, build and demonstrate a prototype sensor system with complementary image understanding components to facilitate automated extraction of information from image data.

DESCRIPTION: With continuing progress in the development of microelectronics and communications technology, it is becoming increasingly inexpensive to acquire, process and distribute digital image data. While many applications are satisfied by acquisition and distribution of a simple picture, more demanding computer vision applications seek to extract information from the imagery: segment and classify objects; detect and track movement of objects; measure shape, size and/or material properties of objects and surfaces. Innovative concepts are sought to embed image understanding components in novel sensor systems to facilitate automated extraction of information from image data. Development of new products for automated extraction of information from image data (e.g., segmentation and classification of objects; detection and tracking of moving objects; measurement of shape, size and/or material properties of objects and surfaces). This goal may be addressed by (1) hybrid configurations that combine novel imaging concepts and complementary image understanding technology, or (2) software-intensive solutions linking novel image understanding processes to commercial-off-the-shelf (COTS) sensors and computational components. Recent imaging sensor innovations include omni-directional catadioptic cameras, scanning laser range finders, board-level stereo camera systems, video polarization cameras, multispectral and hyperspectral scanners and uncooled thermal arrays. Suitable image understanding algorithms, tailored to the unique characteristics of the sensor, hold the potential for achieving low-cost, high-performance capabilities of specific types of applications. Alternatively, software-intensive solutions linking commercial-off-the-shelf (COTS) sensors and computational components with novel image understanding processes may be proposed to address specific terrestrial or airborne applications. In any case, the imaging phenomenology, the processing strategy and the desired capability must be clearly defined for a proposed effort.

PHASE I: Refine concept for a sensor system which couples image understanding components to sensor operating characteristics. Specify targeted commercial and military applications. Identify critical design issues and conduct experiments to establish feasibility. Analyze predicted performance. Deliver a specification, development plan, test plan and cost estimate for the prototype system.

PHASE II: Implement the prototype system as designed. Demonstrate system performance in accordance with test plan. Evaluate accuracy and operating characteristics of the implemented system. Prepare marketing plan for targeted commercial and military applications.

PHASE III DUAL USE APPLICATIONS: With the rapidly increasing use of low-cost, computer-interfaced imaging devices in both commercial and military applications, there is great potential for products that successful automate application-specific image analysis tasks and eliminate the need for exclusive human interpretation. Potential Phase III dual use applications arise in many defense and civilian domains: security surveillance and monitoring; access controls; personal identification and authentication; automated and computer-assisted target recognition; analysis of intelligence and earth resources imagery; autonomous navigation of ground vehicles and robots; cartography; modeling and simulation; law enforcement; medical imaging; and manufacturing process control and quality control. The ability to package increasingly smart sensors as lower-cost

system components will address existing market needs for automated and semi-automated vision components while expanding the market for analysis of visual data in many fields.

KEYWORDS: Sensors; Image Understanding; Computer Vision; Real-Time Image Processing.

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2. DARPA Airborne Video Surveillance Home Page <http://www.darpa.mil/iso/avs/>
3. *Proceedings of the 1997 Image Understanding Workshop.* Morgan Kaufmann Publishers, San Francisco, California. ISBN: 1-5586-490-1.
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DARPA SB991-015 TITLE: Information System Vulnerability Assessment Tools

KEY TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Creation of tools to determine information system vulnerability to cyber attack.

DESCRIPTION: Research and development leading to information system vulnerability analysis tools that enable system security officers and administrators to map information systems, determine overall security posture, and identify vulnerabilities to cyber attack. Further, the developed tools will provide risk-balancing alternatives, i.e., measures that can be taken to offset identified vulnerabilities. Commercial vulnerability assessment tools look for "known" vulnerabilities in specific components. DARPA is looking for assessment tools that look for strategic vulnerabilities in systems including vulnerabilities that are not yet known. Efforts may address any information system analysis methodologies for which significant leverage and increased assurance can be demonstrated. Scalable, comprehensive tools that measure risk factors in a distributed, network-centric computing environment are of particular interest. Efforts may either modify existing codes, algorithms, or tools or create new ones, but in all cases proposals must clearly state how system integrity, availability, and confidentiality vulnerabilities will be identified and measured. Important measurement is how well the tools predict where real red teams attack the system and the level of difficulty they face in successful attack.

PHASE I: Define architectures, methodologies, algorithms, and system level approach to information system vulnerability analysis. Identify potential commercial-off-the shelf (COTS) applications to be integrated into vulnerability analysis tools.

PHASE II: Develop the vulnerability analysis tool(s) including integration of COTS. Demonstrate tool effectiveness and scalability in a DARPA Information Systems Office large scale demonstration such as the Information Superiority Technology Integration (ISTI) series (a series of integration experiments to begin in September 1998 to take on the challenge of creating large integrated systems to meet the tempo and functional challenges of the Chairman of the Joint Chiefs of Staff's Joint Vision 2010). Complete tool documentation and documentation of test cases and results must be delivered.

PHASE III DUAL USE APPLICATIONS: Effective information system vulnerability analysis tools will have widespread commercial application. All major businesses, world-wide, depend on information systems for day-to-day operations and are increasingly concerned, as is the Department of Defense, about system security and information assurance. A risk assessment tool will be readily marketable in the commercial environment.

KEYWORDS: Vulnerability Analysis, Information Systems, Cyber Attack, Information Assurance, Risk Assessment, Algorithms

DARPA SB991-016 TITLE: Dialog Interaction with Video for Expert Knowledge Transfer

KEY TECHNOLOGY AREA: Human Systems Interface

OBJECTIVE: To develop, demonstrate and evaluate a method for cost-effective interaction with humans possessing special expert knowledge who are captured on video (e.g. Colin Powell). The focus is on using spoken language dialog interaction for information access and extraction of lessons learned.

DESCRIPTION: Microprocessor, digital video, and speech recognition technologies have progressed to the point that it is now possible to engage in simulated problem-solving interaction with video characters. There are a plethora of opportunities to employ this method in communications and training in the Government and private sector. This effort will define a cost-

effective method for using these technologies in a "lessons learned" environment. The method must support individualized, active user participation in simulated situations. The concept for operation is that expert knowledge in the form of individuals recorded on video will be available to users through a natural, voice-driven human/computer interface. Scenarios concerning military and commercial affairs of national interest will be developed and field tested to: 1) Determine user acceptance of this technological approach to knowledge gain; and 2) Measure the efficiency and effectiveness of the overall learning gain from this virtual reality approach to knowledge transfer. The research will also include the investigation of reuse of existing video footage for these programs.

PHASE I: Develop a prototype of a system that supports dialog interaction with a person captured on video used to gain "lessons learned knowledge". For example the interaction may be with a logistics planner captured in video who would answer both general and specific questions of how to plan logistics support for a crisis response civilian evacuation. The user would be a military office in staff college who is focusing on joint planning. There must be a plan to conduct an experiment to determine user acceptance of the method.

PHASE II: Expand the prototype into a series of expert knowledge programs. Evaluate the efficiency and effectiveness of the learning gain achieved from the method with rigorous, controlled experiments.

PHASE III DUAL USE APPLICATIONS: Demonstration of this technology and its potential provide significant educational benefits in a broad spectrum of training applications in both commercial and military environments.

KEYWORDS: Human Systems Interface, Dialog Interaction, Expert Knowledge Transfer, Speech Recognition, Simulated Problem-Solving Interaction

DARPA SB991-017 TITLE: Computationally Efficient Detection of Vehicles in High Clutter Environments in Synthetic Aperture Radar Imagery

KEY TECHNOLOGY AREA: Sensors

OBJECTIVE: Development of robust target detection systems capable of mitigating naturally induced false alarms in medium resolution magnitude-detected microwave synthetic radar imagery from airborne collection systems, and for automated use of scene context in Foliage Penetration (FOPEN) Synthetic Aperture Radar (SAR) imagery to detect camouflaged or concealed targets.

DESCRIPTION: Research and development leading to unique algorithms and software systems that are capable of detecting (with very high confidence and low false alarm rates) radar signatures of both individual and groups of vehicles in areas with significant background clutter density resulting from target-like natural and man made objects. Efforts should focus on computationally efficient algorithms capable of real time implementation, utilizing magnitude detected imagery of 1m IPR or greater. Efforts of interest include post-detection filtering to eliminate vegetation-induced false alarms; novel detectors to permit detection of closely spaced targets and unique approaches to the rapid rejection of false alarms induced by man-made confusers. It is desirable to further automate rejection of false alarms through the use of context to reduce the number of image analysts required and the volume of data, which must be recorded or data linked to the ground. Much of this contextual information such as roads, tree-lines, lakes, terrain slope, vegetation density, etc., can be extracted from radar imagery. This information is then used in conjunction with an object detection, and is used to rank the likelihood that the object is a target of interest. In addition to in-scene features, such information may be extracted from archived FOPEN or conventional Radar and Electro-Optical (EO) surveillance. These approaches should be designed to serve as the initial screening approach for multistage automated/assisted target recognition/imagery analysis systems. Efforts may either modify existing codes, algorithms, or tools or create new ones, but in all cases proposals must clearly state what improvements are expected over approaches in the current literature for what real world data sets and scenarios.

PHASE I: In detail, define the approach, algorithm, and quantify the expected detection performance benefits through simulation and experiments with limited data sets.

PHASE II: Create a real time implementation of a tool that embodies the algorithm and demonstrate the performance on significant data sets collected from an operational surveillance platform. Analyze and document performance.

PHASE III DUAL USE APPLICATIONS: The development of advanced detection approaches for use with airborne sensors offers significant advantages in the growing application of airborne remote sensing data to problems such as land use planning, demographic analysis and disaster relief planning. Efficient detection approaches would permit automated analysis of vehicle density and other key metrics from remote sensed data; thereby greatly reducing the scope of the labor and skill intensive imagery analysis required to convert raw data into marketable products. It is expected that such improvements would result in greatly reduced cost and significantly increased timeliness for geospatial information derived from remote sensing.

KEYWORDS: Imagery Analysis, Target Detection, Synthetic Aperture Radar, Automated Target Recognition, Foliage Penetration Radar

DARPA SB991-018 TITLE: Robust Adaptive Control Technology for Dependable Systems

KEY TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Technology for (1) Commodity software-enabled controllers for autonomous systems, and (2) self-improving systems

DESCRIPTION: Innovative R&D is sought for: (1) Constructing dependable software-based control systems to meet the demands of Defense applications that must push performance envelopes and coordinate actions while operating under highly unpredictable circumstances. Of interest are (a) strategies for robust, adaptive control that is readily tailored to a specific application; (b) approaches that exploit physical/engineering models for the accurate description, prediction and sensing of subsystem status and environmental conditions; and (c) mode design and coordinated mode transition management for integrated and cooperating systems. The control strategies should be realized in the form of a toolkit enabling rapid construction of controllers for autonomous applications along with benchmarks to evaluate a system's ability to perform its assigned tasks under various conditions, reliably and safely. (2) Self-improving and self-correcting software systems. Self-improving software evaluates its own behavior and changes behavior when it is not accomplishing its goals or when better functionality or performance is possible. The adaptivity should not require specific adaptive techniques such as neural networks or genetic programming, but instead rely on knowledge of the software's mission, construction, and behavior. Runtime management for adaptivity should be addressed.

PHASE I: Demonstrate feasibility of concepts on a relevant application providing convincing evidence of an innovative, dependable software-based control or auto-adaptation capability not otherwise attainable. Define benchmarks and quantitative evaluation strategy. Complete detailed design of control software toolkit and/or auto-adaptation runtime system and implementation plan.

PHASE II: Implement in full and demonstrate the technology on relevant application on a commodity processor. Full documentation is required of the innovative technology developed and an operational description for the demonstration application. Evaluate the system performance.

PHASE III DUAL USE APPLICATIONS: Commercial applications benefiting from this research include vehicle control, environmental control, medical monitoring and support systems, security systems, robots, and electronically integrated systems of consumer products. Military applications that should benefit from the research include integrated avionics and flight control, autonomous or semi-autonomous multi-vehicle systems, electronic warfare countermeasure systems, automatic target recognition, autonomous sensor/actuator systems, and control of micro-electromechanical systems for detection of biological and chemical agents.

KEYWORDS: Control Systems, Distributed Control, Software Controllers, Adaptive Systems, Distributed Systems, Agent-Based Software, Autonomous Systems

DARPA SB991-019 TITLE: Network Management

KEY TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Technology for automatic diagnosis and correction of network problems

DESCRIPTION: Computer networks that tie together organizational information resources are increasingly complex in their services and increasingly fragile, due to inefficient resource use resulting in poor performance or from direct attacks that misappropriate or stress resources. DARPA solicits research into the use of distributed, cooperative pattern-matching and reasoning systems that can represent performance and security constraints and models in a unified framework and automatically diagnose and correct problems. Such systems must be inherently robust by being able to resolve inconsistent views, by dynamically adjusting monitoring capabilities, and by using a federated and dynamic processing model that does not require central control. The system must take into account its own dependencies on the network substrate as part of its reasoning and corrective procedures.

PHASE I: Develop the pattern matching capability in the domain of network elements (routers, hubs, bridges, firewalls, etc.), represent the constraints of performance and security for at least 10 elements, and demonstrate the distributed problem-solving capability for at least three denial of service attacks described by CERT (the Computer Emergency Response Team organization) within the previous 18 months. The corrective actions taken after the diagnosis should leave the system in a

state that satisfies (perhaps only minimally) the performance and security requirements of the organization. The architecture should be easily extensible and capable of eventually handling up to 10,000 network elements.

PHASE II: Develop a prototype for a commercial product that could interoperate with other network management and security maintenance tools.

PHASE III DUAL USE APPLICATIONS: Commercial applications benefiting from this research include network diagnostic and management and security management tools.

KEYWORDS: Network Management, Security Management, Network Diagnosis, CAD, Network Survivability, Self-Configuring Networks

DARPA SB991-020 TITLE: Human Information Interaction

KEY TECHNOLOGY AREA: Human Systems Interface

OBJECTIVE: Address one or more of the following capabilities.: (1) Develop innovative techniques for high precision discovery, search, and retrieval of multimedia information accessible via the World Wide Web; (2) Create a device to allow individuals and groups to view stereographic displays with the unaided eye.

DESCRIPTION: (1) High Precision Web Search. Information discovery, search, and retrieval technology is rooted largely in algorithms built for centralized, relatively homogeneous collections. These algorithms do not scale well to the needs of users depending on highly distributed, heterogeneous, multimedia resources such as the World Wide Web, particularly in time-critical situations. This subtopic seeks innovative approaches that enable Web-accessible, multimedia information resources to be retrieved quickly and precisely, without overlooking key sources. (2) Unencumbered Viewing of Stereographic Displays. Research and development leading to the design and prototyping of mechanisms and display devices that enable individuals and groups to view stereographic displays without wearing shutter glasses or polarizing glasses. Efforts may address any novel approaches that will enable people to view stereographic displays without the aid of glasses, goggles, or other encumberances. Efforts of interest include techniques for allowing both individuals and groups of between two and ten people to comfortably view stereographic displays. Efforts may either modify existing techniques and devices or create new ones, but in all cases proposals must clearly state what specific viewing characteristics are expected for what types of display devices and under what conditions.

PHASE I: (1) High Precision Web Search. Evaluate the feasibility and effectiveness of the proposed concepts through analytical studies or empirical experiments. A successful Phase I will have rigorously tested the proposed ideas in a laboratory environment and will demonstrate significant performance improvements over current approaches, using well-defined metrics to be included in the initial proposal. (2) Unencumbered Viewing of Stereographic Displays. In detail, define the proposed technique for allowing unencumbered viewing of stereographic displays. Produce a prototype suitable for use by a single individual.

PHASE II: (1) High Precision Web Search. Build a scaleable prototype for the WWW and evaluate its utility for crisis intervention and management. A successful Phase II will engage a Defense customer in the test and evaluation phase, will evaluate the prototype's performance in a realistic setting, and will report performance using metrics derived from those initially proposed. (2) Unencumbered Viewing of Stereographic Displays. Extend the prototype to enable unencumbered viewing of stereographic displays by groups of up to ten people. Apply the prototype to a military scenario such as shared viewing of a stereographic sandtable. Complete documentation of test cases and results must be delivered.

PHASE III DUAL USE APPLICATIONS: (1) High Precision Web Search. The WWW continues its geometric growth worldwide, both in terms of its total number of users and the information accessible. Significant improvements in information organization, indexing, discovery, search, and retrieval, considering not only the attributes of the information but also the characteristics of the end user are of great value to essentially every Web user. In particular, those users whose work is driven by specific, time critical, strategic or tactical requirements will benefit most directly. This specifically includes Defense analysts, but also includes all serious information users dependent on high quality network-accessible information. (2) Unencumbered Viewing of Stereographic Displays. The development techniques and devices for unencumbered viewing of stereographic displays will expand the commercial markets for both stereographic imaging and television systems. Availability of such techniques and related devices could significantly improve the ability of pilots to interpret 3-D data displays in airplane cockpits.

KEYWORDS: (1) High Precision Web Search: Information Discovery, Search, Information Retrieval, Intelligent Agents, Filtering, Metadata, Digital Libraries, Categorization, Query Formulation. (2) Unencumbered Viewing of Stereographic Displays: Stererograhic Displays, 3-D Imaging, Shutter-Controlled Lenses, Polarizing Lenses, Eyes-Free Viewing Systems.

DARPA SB991-021 TITLE: Low-Profile/Conformal Antennas for Ultra-Wideband Airborne Sensors

KEY TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop electrically small, low profile antennas in the HF/VHF/UHF bands to maximize angle-time-frequency diversity in multi-mode airborne applications.

DESCRIPTION: Perform research and development leading to innovative antenna solutions for airborne applications, including Unmanned Aerial Vehicles (UAVs). Sensor applications include Counter Camouflage, Concealment and Deception (CC&D), Synthetic Aperture Radar (SAR), Ground Moving-Target-Indication (GMTI), and passive location of emitters / targets. Adaptive nulling of jammers and Radio-Frequency Interference (RFI) and Space-Time Adaptive Processing (STAP) techniques allow detection of slow ground targets within the main beam clutter and stationary targets in heavy interference. Similar processing allows the isolation and location of targets based upon passive detection of onboard emitters. These techniques, however, require very high percentage bandwidths, and long (in wavelengths) spatial extents. Much of the aircraft skin may need to be occupied by antennas. Thus, innovative solutions to achieve required performance (bandwidth and gain) without intruding into the air-stream or the interior of the aircraft or UAV are needed. High instantaneous bandwidth performance is desirable, but very fast switchable/tunable solutions are suitable in many applications.

PHASE I: In detail, identify enabling technologies, system approach, and paper design. Demonstrate performance through electromagnetic modeling and simulation or scaled models.

PHASE II: Manufacture and test a prototype of an antenna. This must include calibrated amplitude and phase measurements over 4 pi sterradians and over the intended frequency band.

PHASE III DUAL USE APPLICATIONS: Ultra-wideband SAR is being developed under the DARPA GeoSAR program and future systems and upgrades to better operate in heavy interference. Other civilian and commercial applications include law enforcement, counter-drugs, and search-and-rescue.

KEYWORDS: Conformal, Low-Profile, Antennas, Arrays, STAP, Wide-Band, SAR, GMTI, Radar

DARPA SB991-022 TITLE: High - Low Altitude Single Soldier Precise Delivery Systems

KEY TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Design/develop single soldier precise delivery systems capable of insertion from high or low altitudes.

DESCRIPTION: Existing airborne/air assault delivery systems rely on parachute or helicopter based delivery systems to position soldiers in tactical environments. These delivery systems however often place units/soldiers in a vulnerable position, and result in a linear (airborne drop zone) or group based (air assault insertion point) delivery. An alternative to this would be to develop delivery systems for soldiers that deliver them to the precise position at the correct time to initiate tactical combat operations in a novel way. Efforts to develop automated glider or low thrust based manned delivery systems for the single soldier from 5,000 to 70,000 feet are of interest. Systems would be highly survivable, possess autonomous positioning capability (within 10m), organic sensor capabilities Electro-Optical/Infrared/Radio Frequency (EO/IR/RF), organic communications, and capable of transporting up to 300 lbs. of soldier and combat equipment. Of course these delivery systems must be capable of providing for the health maintenance of the soldier to be delivered to the surface, in terms of shock {g-forces}, oxygen, etc. As an automated system, the occupant would not be "in the control loop". The system would be survivable against a variety of threats, in terms of signature management and materials, and must survive the shock of deployment and landing, so as to be capable after retrieval of subsequent reuse. Efforts of interest include horizontal to vertical glide/thrust ratio of 10:1 or greater (in order to provide significant standoff delivery capability). Innovative research and technologies in the areas of advanced glider techniques and materials, autonomous flight control systems, lightweight/thermally resistant/frequency selective materials, miniature low power sensors, novel thrust mechanisms and shock removal techniques {for human health maintenance} would be an integral part of such a concept and are highly desirable.

PHASE I: Concept definition and preliminary design of delivery systems. Quantify expected benefits through design, and simulation/modeling. Focus on aeronautics, environment and soldier survivability capabilities.

PHASE II: Critical design and sub-scale prototype development. Conduct preliminary analysis of navigation/positioning, communication, and sensor capabilities.

PHASE III DUAL USE APPLICATIONS: The development of precise soldier delivery systems will be leveraged into markets providing delivery capability for firefighters into remote regions, or environmental disaster areas. The development of these type of systems could also be leveraged into entertainment markets or as alternatives for sport parachuting, hang gliding, and traditional gliding.

KEYWORDS: Manned Airborne Systems, Glider, Combat Systems

DARPA SB991-023 TITLE: Technologies Enabling Development of Affordable High-Speed Air Vehicles

KEY TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Creation of affordable high-speed air vehicle concepts.

DESCRIPTION: Research and development of key technologies which lead to revolutionary high-speed air vehicle concepts. Efforts should address the application of such technologies to long range, high supersonic and hypersonic air vehicles, but innovative approaches which lead to revolutionary, affordable hypersonic vehicle concepts are of particular interest. Efforts of interest include technologies which enable smaller, lighter or more efficient vehicle designs or innovative propulsion systems. Efforts should include execution of critical experiments to demonstrate key technologies in ground or flight test.

PHASE I: In detail, define how application of the proposed technology to the design of a high-speed air vehicle makes it affordable, including a conceptual vehicle design, and quantify the expected benefits over similar, existing vehicle designs.

PHASE II: Perform technology developments and demonstrations of critical technologies which increase the technology readiness and reduce the development risk of affordable high-speed air vehicles. Improvements in analytical tools and analyses over those in Phase I should be demonstrated. Vehicle designs should be matured and benefit analyses refined to reflect the results of developments and demonstrations. Complete documentation of the results of tests, analyses and design studies must be delivered.

PHASE III DUAL USE APPLICATIONS: The development of affordable high-speed air vehicles will expand the commercial markets for passenger and cargo aircraft. Dramatic reductions in travel time between the United States and Pacific Rim destinations would offer significant economic and political benefits.

KEYWORDS: Weakly-Ionized Gas, Hypersonics, Affordable

DARPA SB991-024 TITLE: Three-Dimensional Image Projection

KEY TECHNOLOGY AREA: Sensors

OBJECTIVE: Development of a three-dimensional, color-image projection system that creates convincing images in air.

DESCRIPTION: A tactical 3-D volumetric display system for theater use will spread disinformation and impose surprise on enemy forces, as well as improve friendly force survivability and increased lethality. This requires development of real, opaque, 3-D images in open atmosphere. Image opacity, for hidden line obscuration, is essential for the realism of the projected images, and to provide a wide viewing angle. An experimental study of the image opacity and intensity must be performed to develop and define image projection requirements for generation of real images.

PHASE I: A detailed feasibility analysis is required. This study should include a physics-based quantitative assessment of opacities achievable, size scales (of images and range to the projection system), and color rendering ability as a function of atmospheric and lighting conditions (ranging from indoor environmentally controlled to field environments).

PHASE II: Demonstrate the ability to generate complex volumetric images in air. This demonstration should quantitatively assess how real the image appears under various (and varying) environmental conditions, and as a function of range to the image.

PHASE III DUAL USE APPLICATIONS: A wide range of Dual-Use opportunities exist, including; movie making, advertising, computer games, virtual reality, remote conferencing, and immersive training.

KEYWORDS: Image Rendering, Image Projection, 3-D Image, Denial and Deception, Volumetric Display

DARPA SB991-025 TITLE: Collision-Avoidance Sensors for Micro Air Vehicles

KEY TECHNOLOGY AREA: Air Vehicles

OBJECTIVE: Develop collision-avoidance sensors for Micro Air Vehicles.

DESCRIPTION: Micro Air Vehicles (MAVs) are defined by DARPA to be affordable military air vehicles less than 15 cm in length, width or height, that are capable of performing useful military missions such as local area reconnaissance. They are envisioned to be operated by the individual soldier in the field. For missions in urban and other confined environments, these autonomous vehicles will require collision-avoidance sensors to prevent collision with obstacles like walls, poles, and wires. MAVs include both fixed-wing and hover configurations. Typically, fixed-wing vehicles will weigh less than 100 grams and hovering MAVs are likely to weigh less than 300 grams. To meet typical weight and power constraints for MAVs, collision-avoidance sensors are likely to have to weigh less than 10-40 grams and to require less than 1-2 watts of average power. Obviously, the less the better. Range out to 50 meters is desirable, with update rates of 1 kHz or better. Ideally, the sensor system should recognize ground and distinguish it from approaching obstacles, and facilitate maneuver in cluttered environments like urban canyons or sparsely forested terrain.

PHASE I: Develop a detailed design for an MAV collision-avoidance sensor system and a plan to build and test the system. Describe expected performance. Show feasibility of the concept, and identify major barriers to be overcome.

PHASE II: Build an MAV collision-avoidance sensor system and demonstrate it in a suitable flight test vehicle (such as a model airplane).

PHASE III DUAL USE APPLICATIONS: It is anticipated that MAVs will find a host of civilian as well as military applications, such as aerial photography, and fire, police and rescue operations. Collision-avoidance sensors may also serve as altimeters or ranging devices that will facilitate MAV civilian applications.

KEYWORDS: Micro Air Vehicles, Collision Avoidance, Range Sensors

DARPA SB991-026 TITLE: Rankine Bottoming Cycle for Military Diesel Engines

KEY TECHNOLOGY AREA: Ground Vehicles

OBJECTIVE: Advanced research of Rankine Bottoming Cycles for highly-compact and increased-efficiency diesel engines.

DESCRIPTION: Modern military diesel engines use 4-valve, direct-injection, turbocharged technology to achieve power densities of 2 to 3 lbs/hp at peak thermal efficiencies of 38 to 42%. Ongoing DARPA programs are seeking higher diesel efficiencies and power densities through electro-turbo compounding and high-pressure cycles. If fully successful, these programs will boost efficiency to levels approaching 50% at power densities of 1.5 to 2.0 lbs/hp. Given the most aggressive development progress, the 50% thermal efficiency results in 9,550 BTUs of exhaust and radiator waste heat for every pound of diesel fuel burned. This waste heat requires an additional parasitic power to operate cooling fans and also results in a thermal signature that is undesirable. Past investigations of Rankine Bottoming Cycles for diesel engines have resulted in complex and bulky systems that would not fit within a combat vehicle. The present effort seeks to develop highly-compact solutions that integrate the full-vehicle thermal management function and result in net volume reductions and fuel economy increases.

PHASE I: Preliminary design of full power system including: thermodynamic calculations, detailed design of critical components, Computer Aided Design (CAD) layout with weight and volume estimates.

PHASE II: Design, build and test for 100 hrs. prototype developed in Phase I over power and environmental conditions. Provide estimate of production cost, weight and volume in production scale.

PHASE III DUAL USE APPLICATIONS: Dual use applications for this technology include both commercial ground and maritime vehicles. The fuel economy benefits realized by the higher operating efficiencies will be very attractive to the commercial market. Reduction in net volume will also be attractive to manufacturers of smaller systems.

KEYWORDS: Diesel Engines, Rankine Bottoming Cycle, Power Densities, Turbo-Charge Technology, Thermal Management, Thermal Efficiency, Fuel Economy, Combat Vehicle

DARPA SB991-027 TITLE: Wavefront Sensing for Closed-Loop Adaptive Optics in Extended Scenes

KEY TECHNOLOGY AREA: Sensors

OBJECTIVE: Development of real-time adaptive optics for imaging seekers using only extended scenes.

DESCRIPTION: There are many missiles that have imaging seekers. Because of the seeker's operating environment, the imagery is significantly degraded by a variety of causes including boundary-layer turbulence, thermal heating of the window and optical elements, and jitter. There is a need for on-board adaptive optics (AO) which would correct optical aberrations in real-time and thus allow one to retrieve fine-resolution imagery. Improved imagery delivered in real-time would significantly increase performance of the seekers, particularly in the final stages of aim-point selection, and allow for a dramatic enhancement of surgical capabilities in a tactical setting. Conventional AO (widely used in astronomy) uses wavefront sensors (WFS) which rely on a point-like beacon being in the scene. In many missile scenarios, extended scenes are available but there is no beacon available (e.g., air-to-ground, ground-to-ground missiles). Furthermore, the update rates of the missile seeker can be in the hundreds of hertz stressing both the signal-to-noise (due to short integration times) and processing power needed to minimize latency. Thus there is a need for an AO system which uses a WFS able to operate on extended scenes with update rates up to several hundred hertz.

PHASE I: In detail, define the algorithm for exploiting extended scene imagery to adaptively compensate for degradation in imagery. Quantitatively assess the image quality enhancement expected for an environment typical of air-to-ground and ground-to-ground seekers. Estimate the computational burden (including memory, I/O throughput, and processing power) necessary to develop a real-time capability for a system operating at hundreds of hertz. Assess the aim point accuracy achievable by employing this real-time AO system.

PHASE II: Create a laboratory brass-board system of the AO. Perform a series of tests that accurately simulate the boundary-layer turbulence, thermal heating, and jitter anticipated in a fielded missile system. Quantify the actual performance enhancement gained by using the developed AO algorithm and compare with the predictions provided under Phase I. Explain any discrepancies between predicted and actual results.

PHASE III DUAL USE APPLICATIONS: The technology developed under this SBIR, would also have applications in manufacturing scenarios that rely on real-time inspection/monitoring in environments where there are dynamically changing aberrations. A specific example of such an application is that of monitoring a manufacturing process in an oven. It would also benefit the astronomical and military space surveillance community where observations of extended objects (e.g., planets, nebulae, or satellites) is desired and no guide stars are within the field-of-view of the sensor.

KEYWORDS: Adaptive Optics, Imaging Seekers, Missile Sensors, Optical Aberrations, Optical Turbulence

DARPA SB991-028 TITLE: Airborne Free Air Turbulence Measurement Device

KEY TECHNOLOGY AREA: Sensors

OBJECTIVE: Development of an aircraft onboard, clear air turbulence mitigation system capable of accurately predicting turbulent disturbances along the aircraft flight path and calculating the appropriate control surface response to minimize turbulence induced loading.

DESCRIPTION: Research and development leading to a prototypical onboard aircraft turbulence mitigation system. Efforts may address various Light Detecting & Ranging (LiDAR) and/or radar techniques, or it may include other innovative approaches to measure flow fields. Research should be focused on: (1) making accurate 3-D turbulent velocity measurements with a spatial accuracy and look ahead distance appropriate for aircraft responses (work in this area should build upon current NASA sponsored flight testing), (2) calculating optimal control system responses that minimize aircraft loading and displacement, (3) proving the concept via flight testing, and (4) analyzing potential aircraft design that is optimized (reduced structure, longer airframe life, enhanced operation in adverse conditions, ...) to take advantage of the turbulence mitigation technology. Research should include a comparison of the measured turbulence to an aircraft's actual response for various look ahead distances and turbulent events. Also, the system's ability to function in all weather conditions (clouds, rain, smoke, etc.) should be proven.

PHASE I: Analyze potential system concepts. Estimate reducing G-loading levels in different turbulence conditions via simulation. Determine sensor and control surface requirements. Determine potential system utility in potential DoD applications (transport, reconnaissance unmanned aerial vehicles (UAVs), carrier landing, etc.

PHASE II: Design, build, and flight test a proof-of-concept system capable of measuring the 3-D turbulent velocities ahead of an aircraft and reducing G-loading. Data should be collected which compares the sensor measurements with the actual

event as seen by the aircraft to allow validation of modeling approach. Detailed modeling of DoD applications should be performed.

PHASE III DUEL USE APPLICATIONS: This type of turbulence measurement device could be incorporated into an aircraft's flight control system as part of a predictive turbulence mitigation system. The goal is to dramatically reduce the loads on the aircraft through the use of the control surfaces. This could have dramatic effects both for passengers of civil aircraft as well as military passengers and pilots on long low altitude flights. In addition, this system could be used to reduce the required structural strength of a UAV by limiting the peak loads that aircraft will face. The lighter aircraft could therefore have a longer endurance or carry additional payload.

KEYWORDS: Atmospheric Turbulence, Clear Air Turbulence, Doppler LiDAR, Doppler Radar, Gust Alleviation, Turbulence Mitigation

DARPA SB991-029 TITLE: Actuator Technologies for Micro-Adaptive Flow Control

KEY TECHNOLOGY AREA: Air Vehicles

OBJECTIVE: Develop new, active, flow-control actuators that perform large-scale flow control with small-scale flow manipulations.

DESCRIPTION: Micro Adaptive Flow Control (MAFC) is defined by DARPA as the control of large-scale flow fields using small-scale actuators in highly sensitive regions of the flow field. By combining innovative flow-actuator technologies with adaptive control strategies, DARPA seeks to develop flow-control technologies with the potential for radical gains in aerodynamic or hydrodynamic performance. Robust actuators are needed to enable realization of these technologies in systems-level applications that may include aircraft, maritime vehicles, munitions, and engines. Emerging technologies like Microelectromechanical Systems (MEMS) and Smart Materials have enabled exploration of new concepts for flow actuation. Substantial performance gains have been indicated by several research efforts (ref. 1-3). It is the intent of this SBIR to expand the current set of active flow control devices. Proposed actuator designs should be capable of effective operation under flow conditions, power levels, displacements, forces and bandwidths that are commensurate with real systems-level applications. Proposals should describe proposed actuator technologies and anticipated performance benefits in the context of particular systems applications and operating conditions.

PHASE I: Define a plan to manufacture active flow-control actuators and a plan to benchmark the actuator performance. Estimate the expected performance of the actuator and define the systems application for it.

PHASE II: Build the actuator and test it under realistic flow conditions relevant to the applications described in Phase I.

PHASE III DUAL USE APPLICATIONS: It is anticipated that new actuator technologies will build new markets for MAFC technology by enabling performance gains in aircraft, maritime vehicles, munitions, and engines. Potential areas of enhanced performance include higher lift, greater maneuverability, reduced drag, greater range, lower noise, higher thrust to weight ratios, and greater precision. Many of these will have civil as well as military applications.

KEYWORDS: Micro Adaptive Flow Control, MEMS, Smart Materials, Aircraft, Maritime, Munitions, Engines, Actuators

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DARPA SB991-030 TITLE: Feedback-Controlled Predistortion Linearizer for Microwave Power Amplifier

KEY TECHNOLOGY AREA: Command, Control and Communications (C3)

OBJECTIVE: Development of feedback control of a predistortion linearizer to maintain optimal predistorter tuning.

DESCRIPTION: High data rate Radio Frequency (RF) communication systems exploit bandwidth-efficient modulation schemes, which, in turn rely on highly linear power amplifiers. Linearization schemes are used to reduce distortion with

minimum loss of amplifier efficiency. Predistortion is a proven linearization technique, but it is incapable of compensating for changes in power amplifier characteristics. By augmenting a predistortion linearizer with feedback control, optimal tuning of the predisdorter can be maintained despite power amplifier drifts caused by aging, temperature variation, or other factors.

PHASE I: Evaluate candidate approaches, including different predistorter topologies and various feedback schemes. Select one approach based on linearity, subsystem efficiency, and producibility.

PHASE II: Build a breadboard linearized amplifier based on the approach selected in Phase I, and measure its performance when exposed to temperature variations and other variations designed to simulate the effects of aging. Compare the measured performance with the results predicted in Phase I, and use the results to carry out one iteration of the design.

PHASE III DUAL USE APPLICATIONS: The technology developed in this SBIR could be used in space-based or terrestrial communications systems. There would be immediate application to commercial systems that use multiple carriers per channel, such as cellular telephone base stations, and communications satellites serving mobile users. This technology would also be very useful in bandwidth efficient modulation schemes such as n-QAM.

KEYWORDS: Predistortion Linearizer, Linear-Power Amplifier, Multi Carrier Power Amplifier

DARPA SB991-031 TITLE: Shock-Tolerant Auxiliary Bearing for Magnetic-Bearing Suspensions

KEY TECHNOLOGY AREA: Surface/Under Surface Vehicles/Ground Vehicles

OBJECTIVE: Develop a shock tolerant auxiliary bearing to support magnetic bearings for applications such as flywheel energy storage devices for vehicles.

DESCRIPTION: The development of robust, flywheel-energy storage systems for transportation and high-pulsed power applications requires shock-tolerant auxiliary bearings integrated with magnetic bearings for long life and low-power loss. In particular, for military vehicles the auxiliary bearings must be able to sustain numerous, high-speed shock transients without adversely impacting flywheel system performance. The auxiliary bearings must be very reliable and safe. The auxiliary bearings also provide primary rotor support in the event of a failure of the magnetic-bearing suspension. Magnetic-bearing technology is emerging. This solicitation relates to the auxiliary bearings either separately or integrated with magnetic bearings. Typical military flywheel rotors under development weigh 500-800 pounds, spin at 20,000-25,000 RPM, and have an "inside-out" topology (i.e., the machine stator is inside the rotor).

PHASE I: Develop a concept design supported by appropriate analysis, develop assembly concepts, develop concept designs for a test rig, and specify a test plan. Physical experiments are not required for Phase I, but would improve likelihood of selection for Phase II.

PHASE II: Build, demonstrate and characterize the bearing designed by Phase I. Show that the bearing is robust, safe for flywheel use, and compatible with flywheel requirements. Identify specific flywheel designs to which the bearing will apply.

PHASE III DUAL USE APPLICATIONS: The primary military application is energy storage for hybrid electric-power systems for combat vehicles. The same bearing can be applied to military non-combat vehicles and commercial vehicles, although without the extremely high-pulse power requirements. Application is also possible to other high-performance rotating machinery such as turbines.

KEYWORDS: Flywheel, Bearing, Magnetic Bearing, Energy Storage

REFERENCES:

1. B.T. Murphy, D.A. Bresie, and J.H. Beno, University of Texas at Austin Center for Electromechanics, "Bearing Loads in a Vehicular Flywheel Battery", SAE Technical Paper #970213.
2. Hooshang Heshmat Ph.D., "On the Theory of Quasi-Hydrodynamic Lubrication with Dry Powder: Application to Development of High-Speed Journal Bearings for Hostile Environments", presented at the "20th Leeds-Lyon Symposium on Dissipative Processes in Tribology," Lyon, France, September 7-10, 1993.
3. Steven Ashley, Associate Editor, "Flywheels Put a New Spin on Electric Vehicles", published in Mechanical Engineering, October 1993.
4. R.C. Flanagan, and C. Aleong, Mechanical Engineering, University of Ottawa, W.M. Anderson and J. Olberman, Unique Mobility Inc, Englewood, CO, "Design of a Flywheel Surge Power Unit for Electric Vehicle Drives", Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Volume 4, IECEC-90, August 12-17, 1990, Reno, Nevada.
5. David W. Lewis, Robert R. Humphris, Paul E. Allaire, David V. Taylor, Mechanical & Aerospace Engineering Dept., University of Virginia, Charlottesville, VA 22903, "Shock Loading of Magnetic Bearing Systems", paper # 889467, Proceedings of the 23rd Intersociety Energy Conversion Engineering Conference, 1988 IECEC, July 31-August 5, Denver, CO.

BALLISTIC MISSILE DEFENSE ORGANIZATION (BMDO)
SMALL BUSINESS INNOVATION RESEARCH PROGRAM
Submitting Proposals - Instructions

Send Phase I proposal packages (the unbound original, to make extra copies, and six bound copies (i.e. stapled), to immediately forward to evaluators, of the full proposal, **PLUS** one additional copy of Appendices A and B only) by US mail (or any commercial delivery service). Also, APPENDIX E needs only to be with the unbound original. **DO NOT** attach APPENDIX E to the six bound copies. The mailing address follows and the BMDO SBIR website address is provided.

Ballistic Missile Defense Organization
ATTN: TORI/SBIR (BOND)
1725 Jefferson Davis Highway, Suite 809
Arlington, VA 22202

For Administrative HELP ONLY call: **800-WIN-BMDO**
Internet Access: **www.futron.com/bmdo/sbir.html**

Proposals delivered by other means will not be accepted. Proposals received after the closing date will not be processed. BMDO will acknowledge receipt of proposals, **IF AND ONLY IF**, the proposal includes a self-addressed stamped envelope and a form that needs only a signature by BMDO.

All proposal submission appendices may be downloaded from the DoD SBIR Website at (http://www.acq.osd.mil/sadbu/sbir/appendcs.htm). Furthermore, all companies are strongly encouraged to submit their APPENDIX A and APPENDIX B only, through the BMDO SBIR Website at (http://www.futron.com/bmdo/sbir.html). Submitting the two appendices will allow BMDO to process proposals faster so that evaluations from the government technical reviewers may be received more quickly. It is in the company's best interest to submit their APPENDIX A and APPENDIX B since those proposals will be processed first.

BMDO is working toward providing a ballistic missile defense system and developing a technology base that will allow the Department of Defense to protect the warfighters against increasingly sophisticated and lethal missiles around the world. BMDO accomplishes these efforts through three broad mission focus areas: Theater Missile Defense (TMD), National Missile Defense (NMD), and Advanced Technology Developments (ATD).

TMD systems respond to and protect U.S. forces, allies, and other countries from existing and emerging short to medium range threat missiles, including cruise missiles. Seven Major Defense Acquisition Programs represent the bulk of BMDO investments: PATRIOT Advanced Capability-3 (PAC-3), Navy Area Theater Ballistic Missile Defense (TBMD), Theater High-Altitude Area Defense System (THAAD), Navy Theater Wide, Medium Extended Air Defense System (MEADS), Space Based Laser (SBL), and Airborne Laser (ABL). NMD is concerned with the possibility of a limited ballistic missile strike against the United States (all 50 states). The key component systems currently under consideration include: ground-based interceptors; ground-based radars; upgraded early-warning radars; forward-based X-Band radars; battle management, command, control, and communications (BMC3); and advanced sensor technology developments. External elements to NMD include the existing early warning satellite system and its planned follow-on: the Space Based Infrared System (SBIRS) which include both the HIGH and LOW components. Finally, BMDO depends on advanced technology developments, of all aspects, to invigorate its ability to implement both TMD and NMD systems in response to increasingly sophisticated ballistic missile threats, to include cruise missiles. Therefore, the continued availability of such advanced technology developments has become an increasingly vital and critical element of the overall BMDO mission.

The intent of BMDO, first and foremost, is to seek out the most innovative technology that might enable a defense against a missile in flight -- lighter, faster, stronger, more reliable technologies are all of interest. Proposing companies need not know specific details or requirements of possible BMDO systems, research and development goals, or specific technology needs or requirements, but must understand that potential technologies should have application to ballistic missile defense at some level. (A better fire extinguisher, although it may be new and

innovative and exhibit a potential commercial market, does not support ballistic missile defense requirements at any level.)

Specifically, **BMDO seeks to invest seed-capital, which supplements private sector investment support, in a product with a future market potential (preferably private sector) and a measurable BMDO benefit.** The BMDO SBIR/STTR Program will neither support nor further develop concepts **already mature enough to compete** for private capital or for mainline government research and development funds. BMDO prefers projects that move technology into the private sector market by a market-oriented small company. Phase I proposals should focus on the innovation of the proposed technology. Proposals should illustrate the concept or feasibility, and the merit of a Phase II for a prototype or at the very least a proof-of-concept. Phase II competition will also be judged intensely on future market possibilities and commercialization potential. Phase II proposals may be submitted anytime, for any amount, in any format after the Phase I begins. Unique efforts showing time sensitivity or submitted for *FasTrack* will be given due consideration for Phase II start-up funding and Phase I proposals may include a post-Phase I optional tasking that will permit rapid start-up if the Phase II or *FasTrack* application is approved. The latest information on how BMDO implements its *FasTrack* Program may be found at the website address under the *FasTrack* or Frequently Asked Questions (FAQs).

Principal Investigators who are tenured faculty are **NOT** considered primarily employed by a small firm if they receive compensation from the university while performing the contract; any waiver must be requested explicitly with a justification showing a compelling rational and national need; BMDO expects to grant no waivers.

BMDO intends for a Phase I to be only an examination of the merit of the concept or technology with an average cost under $65,000. Although proposed cost will not affect selection for negotiation, contracting may be delayed if BMDO reduces the proposed cost. **DO NOT** submit the same proposal, or variations thereof, to more than one BMDO topic area; each idea will be judged once in an open competition among all proposals. Furthermore, BMDO performs numerous cross-reference checks within each solicitation and with other DoD components.

Because BMDO seeks the best nation-wide experts in innovative technology, proposers may suggest technical government reviewers by enclosing a cover letter with the name, organization, address, phone number, and rationale for each suggestion. BMDO promises only to consider the suggestion and reserves the right to solicit other evaluations.

Implementation of DoD's Fast Track Policy at BMDO

Rationale for BMDO's Implementation Plan

The Defense Department's SBIR program has implemented a Fast Track policy for companies which, during their Phase I efforts, attract outside investors (government or private sector) that will match Phase II SBIR funding, in cash, at the matching rates described in the solicitation. Companies that obtain such outside cash investments and qualify for the SBIR Fast Track receive:

- a significantly higher chance of Phase II award, and
- interim funding between Phase I and Phase II, as well as expedited processing, to ensure no significant funding delays between Phases I and II.

The following summarizes how the DoD Fast Track policy is implemented at BMDO. This Implementation Plan is specifically required since the BMDO SBIR Program has evolved to the level that most companies competing for a Phase II award from BMDO obtain private-sector investment support – not just companies participating in the Fast Track. In fact, the BMDO SBIR Program, in its decision process for Phase II award selections, uses as a primary selection criterion (but not the only criterion) a company's ability to demonstrate commercial potential by attracting private-sector investment support during the performance of the Phase II. The value that BMDO places on this support depends on a number of factors, including the type of investment support (e.g. cash, support-in-kind, or self-investment), amount of the matching support, and timing of the matching support.

Thus, implementation of the DoD Fast Track policy at BMDO needs to occur in such a way that Phase II proposals with the greatest commercial potential, as measured by the amount of private-sector investment support, receive the highest priority for Phase II award.

BMDO's Fast Track Implementation Plan – "*FasTrack*" – has been in effect since the FY96.1 DoD SBIR solicitation and is approved for implementation by the Under Secretary of Defense for Acquisition and Technology (USD(A&T)).

BMDO's *FasTrack*:

- is consistent with the general principles of the DoD Fast Track policy, described above; and
- has demonstrated a track record of success. Specifically, BMDO implemented its *FasTrack* policy during 1996-1997 using the procedures outlined below, with the approval of the USD(A&T). 31 Phase I projects qualified for BMDO *FasTrack* during this time period -- the highest amount per dollar of SBIR funds of any DoD SBIR component. 30 of these projects were selected for Phase II award and also received interim funding between Phase I and Phase II.

The BMDO *FasTrack* Implementation Plan

a. In General. BMDO implements a *FasTrack* SBIR process for companies which, during their Phase I projects, attract one or more private-sector, outside investors that will match Interim SBIR Funding (between Phase I and Phase II) and Phase II SBIR funding, in cash, and at the matching rates described in subsection (c) below. Such companies shall receive (subject to the qualifications described herein):

(1) Interim Funding of $30,000 to $40,000 between Phase I and Phase II;

(2) BMDO's highest priority for Phase II selection and award; and

(3) An expedited Phase II selection decision and an expedited Phase II award.

Questions about the BMDO *FasTrack*, including any of the provisions discussed below, should be directed to the BMDO SBIR/STTR Program Manager, Mr. Jeff Bond, at 703-604-3538 (FAX -3956). The BMDO SBIR Home Page contains a BMDO *FasTrack* Timeline showing the schedule of events for a company participating in BMDO's *FasTrack* program (see http://www.futron.com/bmdo/3FAST/fasttrk.gif).

b. How to Qualify for BMDO *FasTrack*. To qualify for BMDO *FasTrack*, a company that has received a BMDO-sponsored Phase I award must submit the following five items within four (4) months of the effective date of the Phase I award. (Note: The effective date is the date on which the Phase I contract actually takes effect and the company may begin to incur costs under the contract.)

(1) A completed DoD/BMDO *FasTrack* application form (which follows this Plan). A copy of the completed DoD/BMDO *FasTrack* application must also be sent to the DoD SBIR Program Manager at the address listed on the back of the form.

(2) A Commitment Letter from a private sector, outside investor (or investors) – such as another company, a venture capital firm, or an "angel" investor – stating that the investor(s) will match the Interim Funding and the Phase II funding, in cash, at the matching rates listed in subsection (c) below. The investment must qualify as a "Fast Track investment," and the investor as an "outside investor," as defined in Reference E of the SBIR solicitation (i.e., the investor cannot be an affiliate of the SBIR company). Additionally, under BMDO *FasTrack*, federal, state, and foreign governments do not qualify as valid investors.

The Commitment Letter should state that the investor's funds will pay for work that is connected to the specific SBIR project, and should also describe the general nature of that work. The work funded by the investor may be additional research and development on the project or, alternatively, it may be other activity related to the project (e.g., marketing) that is outside the scope of the SBIR contract. The investor may provide its matching funds to the company contingent on the company's being selected for Phase II (procedures for accomplishing this must be discussed with the BMDO SBIR Program Manager, Mr. Jeff Bond, at 703/604-3538).

(3) A concise Statement of Work and Cost Proposal for the Interim Funding effort (typically less than 4 pages in length).

(4) An Executive Summary of the current status of the Phase I effort (typically less than 4 pages in length).

(5) A copy of the first page of the Phase I contract (i.e. the signature page).

Additionally:

(1) The company must submit its Phase II proposal within five (5) months of the effective date of the Phase I award;

(2) The company must submit a Private Sector Investment Certification (PSIC) within seven (7) months of the effective date of the Phase I award, indicating that the investor's matching funds have been transferred to the SBIR company. The PSIC consists of: (a) a letter, signed by the investor and the company, that states the amount of cash that has been transferred; and (b) documentation to substantiate that the transfer of funds has occurred (e.g. a bank statement, wire transfer, or copies of canceled checks).

If not all the investor's funds are transferred to the company by the end of the seventh month, the company will still qualify for the *FasTrack*. However, it will receive a lower preference for Phase II selection than other *FasTrack* participants, as described in subsection (e) below. Additionally, BMDO will match any investor funds transferred to the company after the seventh month at only a $1 to $1 matching rate, rather than at the more favorable matching rates listed in subsection (c) below. Also, BMDO will only provide installments of Phase II funds to the company after corresponding installments of matching funds have

been transferred from the investor to the company. (e.g., the company and investor must certify that $60,000 in matching funds has been transferred to the company before BMDO will release a corresponding $60,000 installment of Phase II SBIR funds.)

A company which fails to meet these conditions in their entirety within the time frames indicated will generally be disqualified from BMDO *FasTrack* consideration. If disqualified, the company shall still be eligible to compete for a "standard" Phase II award through the regular BMDO Phase II procedures with no penalty.

c. Matching Rates. BMDO *FasTrack* matching rates differ slightly from the matching rates under the DoD Fast Track policy. The BMDO rates are as follows:

(1) For SBIR companies that have 10 or fewer employees **and** have never received a Phase II SBIR or STTR award from any federal agency, the investor's Commitment Letter must state that the investor shall provide at least $1 to match every $4 of Interim SBIR Funding and Phase II funding. (e.g., If the company proposes Interim SBIR Funding of $40,000 and Phase II SBIR funding of $600,000, the investor must provide a commitment of matching funds of $10,000 and $150,000 respectively for the two efforts.)

(2) For SBIR companies that have received fewer than five (5) Phase II SBIR/STTR awards from the federal government, and do not fall into category (1) above, the investor's Commitment Letter must state that the investor shall provide at least $1 to match every $2 of Interim SBIR Funding and Phase II funding. (e.g., If the company proposes Interim SBIR Funding of $40,000 and Phase II SBIR funding of $600,000, the investor must provide a commitment of matching funds of $20,000 and $300,000 respectively for the two efforts.)

(3) For SBIR companies that have received five (5) Phase II SBIR/STTR awards or more from the federal government, the investor's Commitment Letter must state that the investor shall provide at least $1 to match every $1 of Interim SBIR Funding and Phase II funding. (e.g., If the company proposes Interim SBIR Funding of $40,000 and Phase II SBIR funding of $600,000, the investor must provide a commitment of matching funds of $40,000 and $600,000 respectively for the two efforts.)

d. Benefits of Qualifying for BMDO *FasTrack*. A company that qualifies for BMDO *FasTrack* will:

(1) Receive Interim Funding of $30,000 to $40,000 between Phase I and Phase II (However, the Interim Funding plus the Phase I award shall not exceed $100,000).

(2) Receive BMDO's highest priority for selection for Phase II award. Specifically, BMDO shall select the company for Phase II award assuming its project meets or exceeds a "technically sufficient" level, as described in Section 4.3 of the current solicitation. As discussed in subsection (e) below, among *FasTrack* companies, those that receive all of their investor matching funds within seven months after the effective start date of Phase I receive higher preference for selection than *FasTrack* companies that receive some or all matching funds after the seventh month.

(3) Receive notification of whether it has been selected for Phase II award within 60 days after the completion of its Phase I project.

(4) If selected, receive its Phase II award within an average of five months after the completion of its Phase I project, to ensure no significant funding delay between Phase I and Phase II. (Note: Although BMDO makes all of its Phase II selection decisions, the Phase II contracts are processed by other DoD organizations, and BMDO therefore does not directly control the timing of the contract awards. However, most BMDO *FasTrack* awards have been made within five months after the completion of the Phase I effort.)

e. BMDO *FasTrack* Preference Levels. As discussed above, companies that qualify for the BMDO *FasTrack* receive BMDO's highest priority for Phase II selection and award. Among *FasTrack* companies, those that receive all of their investor matching funds within seven months after the effective start date of Phase I receive higher preference for selection than *FasTrack* companies that receive some or all matching funds after the seventh month, as follows:

Preference Level 1 applies to *FasTrack* companies that receive **all** of the matching funds for the Interim effort and the Phase II effort within seven months after the effective start date of the Phase I award.

Preference Level 2 applies to *FasTrack* companies that receive all of the matching funds for the Interim effort but only some of the matching funds for the Phase II effort within seven months after the effective start date of the Phase I award.

Preference Level 3 applies to *FasTrack* companies that receive all the matching funds for the Interim effort but none of the matching funds for the Phase II effort within seven months after the effective start date of the Phase I award.

U.S. DEPARTMENT OF DEFENSE / Ballistic Missile Defense Organization

SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
FASTRACK APPLICATION COVER SHEET

Failure to fill in all appropriate spaces may cause your application to be disqualified

To qualify for the **BMDO** SBIR Fastrack, a company must complete this form and meet the other requirements detailed in the BMDO section of the solicitation (and also on the BMDO SBIR Web Site). Instructions on where to submit this form are on the back.

TOPIC #: ______________ CONTRACT #: ______________________ PHASE I EFFECTIVE START DATE: ______________

SPONSORING DOD COMPONENT: ______________________ PHASE I COMPLETION DATE: ______________

PHASE I TITLE: ____

____

FIRM NAME: ____

MAIL ADDRESS: ____

CITY: ______________________ STATE: __________ ZIP: ______________

TAXPAYER IDENTIFICATION NUMBER: ______________________

NAME OF OUTSIDE INVESTOR: ____

MAIL ADDRESS: ____

CITY: ______________________ STATE: __________ ZIP: ______________

TAXPAYER IDENTIFICATION NUMBER: ______________________

BUSINESS CERTIFICATION:

	YES	NO	MATCHING RATE	
> Do you have 10 or fewer employees and have never received a Phase II SBIR award from the federal government (including DoD)? (if YES, the minimum Investor matching rate is $1 for every $4 in BMDO SBIR funds)	☐	☐	\$1 : \$4	☐
> Have you received 5 or more Phase II SBIR awards from the federal government (including DoD)? (If YES, the minimum Investor matching rate is $1 for every $1 in BMDO SBIR funds)	☐	☐	\$1 : \$1	☐
> If you answered NO to both questions, the minimum Investor matching rate is $1 for every $2 in BMDO SBIR funds.			\$1 : \$2	☐
> Does the outside funding proposed in this application qualify as a "Fastrack investment", and does the investor qualify as an "outside investor", as defined in DoD Fast Track Guidance (Reference E)? If you have any questions about this, call the DoD SBIR Help Desk (800-382-4634). The Help Desk will refer any policy and/or substantive questions to appropriate DoD personnel for an official response.	☐	☐		

Caution: knowingly and willfully making any false, fictitious, or fraudulent statements or representations above may be felony under the Federal Criminal False Statement Act (18 U.S.C. Sec 1001), punishable by a fine of up to $10,000, up to five years in prison, or both.

PROPOSED SBIR INTERIM FUNDING: ______________ INVESTOR MATCHING INTERIM FUNDS: ______________

PROPOSED SBIR PHASE II FUNDING: ______________ INVESTOR MATCHING PHASE II FUNDS: ______________

FIRM CORPORATE OFFICIAL	**INVESTOR CORPORATE OFFICIAL**
NAME: ______________________	NAME: ______________________
TITLE: ______________________	TITLE: ______________________
TELEPHONE: ______________________	TELEPHONE: ______________________
SIGNATURE OF FIRM CORPORATE OFFICIAL DATE	SIGNATURE OF INVESTOR CORP. OFFCIAL DATE

Nothing on this page is classified or proprietary information/data

INSTRUCTIONS FOR COMPLETING APPENDIX D (BMDO)

SUBMISSION:

Submit all items to:

Ballistic Missile Defense Organization
ATTN: TOI/SBIR (Bond)
1725 Jefferson Davis Highway
Suite 809
Arlington, VA 22202

IMPORTANT: Please also send a copy of this application form, when completed, to:
DoD SBIR Program Manager
3061 Defense Pentagon, Room 2A338
Washington, DC 20301-3061

For further information on the BMDO SBIR Program, visit the BMDO SBIR Web Site **http://www.futron.com/bmdo/bmdo.htm**

REQUEST FOR COPIES OF THIS FORM:

Additional copies of this form may be downloaded from the DoD SBIR Web Site (http://www.acq.osd.mil/sadbu/sbir). They may also be obtained from your State SBIR Organization (Reference D) or:

DoD SBIR Support Services
2850 Metro Drive, Suite 600
Minneapolis, MN 55425-1566
(800) 382-4634

Ballistic Missile Defense Organization Topic List

BMDO99-001 - Directed Energy Concepts and Components

BMDO99-002 - Kinetic Energy Kill Vehicles and Components

BMDO99-003 - Sensors

BMDO99-004 CANCELED

BMDO99-005 - Non-Nuclear Power Sources and Power Conditioning

BMDO99-006 - Propulsion and Logistics Systems

BMDO99-007 - Thermal Management

BMDO99-008 - Survivability Technology

BMDO99-009 - Lethality and Vulnerability

BMDO99-010 - Computer Architecture, Algorithms, and Models/Simulations

BMDO99-011 - Optical Computing and Optical Signal Processing

BMDO99-012 - Structural Concepts and Components

BMDO99-013 - Structural Materials and Composites

BMDO99-014 - Electronic Materials

BMDO99-015 - Superconductivity Concepts and Materials

BMDO99-016 - Surprises and Opportunities

BMDO FY99 SBIR TOPIC DESCRIPTIONS

BMDO 99-001 TITLE: Directed Energy Concepts and Components

INTRODUCTION: As part of BMDO's charter to provide for defense against future missile threats, various programs are created to further validate potential technologies to design, develop, and deploy systems in support of various efforts. These new programs provide future decision-makers an option to greatly enhance the capabilities of future TMD and NMD systems. BMDO investigates numerous directed energy technologies for both TMD and NMD applications. As such, a significant investment is made each year in the continued development of increasingly sophisticated systems which may eventually find their utilization in a ballistic missile technology program or major defense acquisition program. All areas of the electromagnetic spectrum provide potential avenues toward finding and disabling a ballistic missile in flight. Furthermore, components, sub-components, and piece part specifics are constantly under evaluation by the various TMD and NMD elements for replacement by the latest technology developments from industry. Current examples under consideration include the Space Based Laser, Airborne Laser, the ground based radar systems associated with THAAD and Patriot, and any other comparable sub-system, component, or subcomponent that can potentially support next generation developments.

DESCRIPTION: BMDO seeks innovative and applied research toward advanced technology developments in the generation, propagation, and detection of directed energy in all forms. Dual-use systems under consideration include, but are not limited to, solid-state lasers (i.e. diode lasers), chemical lasers, excimer lasers, IR/Vis/UV lasers, x-ray lasers, gamma-ray lasers, free electron lasers, quantum lasers, particle beams, radio-frequency (RF) and millimeter wave (MMW), and other unique hybrid approaches including explosively or electrically driven devices. Included herein are such topics as beam control, target acquisition, tracking and pointing, mirrors, beam propagation and steering, optics, antennas, conversion methods, countermeasures, coatings, and micro-optical-mechanical devices incorporating these aspects. Furthermore, any component or subcomponent that is utilized by any of these systems is of interest. Examples of such component specific technology include traveling wave tube amplifiers, timing circuits, pulse forming networks, stimulators, laser/radar arrays, transmit/receive modules, and amplifiers. Components, sub-components, or piece part specifics may be ground, air, or space based in their final application.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (REAL-WORLD EXAMPLES): Company A whose advanced x-ray source is being utilized for waste sterilization was sponsored from this topic. Company B utilized their tunable filters with the citrus industry and for military hyperspectral image applications.

DOD KEY TECHNOLOGY AREAS: Electronic Warfare/Directed Energy Weapons, Electronics

BMDO 99-002 TITLE: Kinetic Energy Kill Vehicles and Components

INTRODUCTION: Potential adversaries are expected to improve their ballistic missile systems and develop countermeasures to U.S. ballistic missile defense programs. The future designs of potential threat improvements that BMDO must address can not be determined explicitly. Broad-based kinetic energy interceptor technologies will potentially contribute to more than one program and possibly to more than one defense area. These kinetic energy weapons benefit from innovations offered in 1) discrimination, 2) agility, 3) accuracy, and 4) affordability. BMDO is constantly investigating potential technologies for both TMD and NMD applications. Additionally, components, sub-components, and piece part specifics are constantly under evaluation by the various TMD and NMD elements for replacement by the latest technology developments from the commercial industry.

DESCRIPTION: Kinetic energy (KE) weapons candidates presently include a variety of ground and space based interceptor concepts including their propulsion sub-system components. System elements include ground-based launchers, axial and divert motors/nozzles, smart projectile components, and endo/exoatmospheric guidance and control mechanisms. Technology challenges for KE systems include: finding the booster hardbody within the plume, differentiating the missile warhead from the various other incoming objects within a threat complex, high performance axial and divert propulsion sub-systems (especially very low mass divert systems), miniature inertial navigation units, array image processing, C.G. Control algorithms, fast frame multicolor and ultra-violet seekers, missile autopilots, acquisition and track; target discrimination, seeker operational environments, lethality/miss distance; aero-optical effects, guidance and fuzing accuracy, shroud separation, window thermal-structural integrity, non-nuclear kill warhead performance, target acquisition in a hostile environment, performance and survivability of electronics in a hostile environment; firing rate, projectile guidance and control and projectile launch

survivability; and, common among all systems reliability, producibility, safety (non-hazardous operation), maintainability, and low cost/low mass; aeroshell ablation control; electromagnetic launches.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (REAL-WORLD EXAMPLES): Company C advanced the metal armature developments for military railgun efforts. Company D began with a bone implantation technology and international investments that resulted from divert motor rocket nozzles. Company E, with a market cap of $60M+, expanded with technology genesis to a dynamic frame seeker and chip-stacking developments. Company F, with a market cap of $356M+, supported ballistic missile defense efforts with their enhanced lethality kinetic energy projectile and has subsequently graduated out of the small business status, but continues to support the DoD in R&D efforts.

DOD KEY TECHNOLOGY AREAS: Air Vehicles/Space Vehicles, Conventional Weapons

BMDO 99-003 TITLE: Sensors

INTRODUCTION: BMDO investigates various sensor technologies for both TMD and NMD applications. As such, a significant investment is made each year in the continued development of increasingly robust and sophisticated sensor systems which may eventually find their utilization in a ballistic missile technology program or major defense acquisition program. All areas of the electromagnetic spectrum provide potential avenues toward finding and disabling a ballistic missile in flight. Furthermore, sensor systems, components, sub-components, and piece part specifics are constantly under evaluation by the various TMD and NMD elements for replacement by the latest technology developments from industry.

DESCRIPTION: Sensors and their associated systems/sub-systems will function as the "eyes and ears" for ballistic missile defense applications, providing early warning of attack, target detection/classification/identification, target tracking, and kill determination. New and innovative approaches to these requirements using unconventional and innovative techniques are encouraged across a broad band of the electromagnetic spectrum, from radar to gamma rays. Passive, active, and interactive techniques for discriminating targets from backgrounds, debris, decoys, chaff, electronic countermeasures, and other penetration aids are specifically sought. Sensor-related device technology is also needed. Examples of some of the technology specific areas are: cryogenic coolers (open and closed systems), cryogenic heat transfer, superconducting focal plane detector arrays (for both the IR and sub-mm spectral regions), next generation InSb focal plane arrays, signal and data processing algorithms (for both conventional focal planes and interferometric imaging systems), low-power optical and sub-mm wave beam steering, range-doppler lidar and radar, passive focal plane imaging (long-wavelength infrared to ultra-violet; novel information processing to maximize resolution while minimizing detector element densities), large format focal plane arrays (cooled and un-cooled), interferometry (both passive and with active illumination), QWIPs, integrated UV/VIS/MIR/IR focal plane arrays, gamma-ray detection, neutron detection, intermediate power frequency agile lasers for diffractive beam steering and remote laser induced emission spectroscopy, lightweight compact efficient fixed frequency radiation sources for space-based ballistic missile defense applications (uv-sub-mm wave), new optics and optical materials. Entirely new and high-risk approaches are also sought. Please indicate the particular identifying letter your specific proposal/technology addresses:

BMDO99-003**A** - Acoustic and Seismic
BMDO99-003**B** - Radar and MMW
BMDO99-003**C** - UV (<0.3 microns)
BMDO99-003**D** - Visible (0.3 - 0.9 microns)
BMDO99-003**E** - IR (>0.9 microns)
BMDO99-003**F** - Gamma/X-Ray
BMDO99-003**G** - Other

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (REAL-WORLD EXAMPLES): Company G, with commercial sales of $15M+, is noted for its laser diode pumped q-switched solid state laser products. Company H, with a market cap of $47M+, transferred its microwave based infrared detector and superconducting millimeter wave mixer technologies for a variety of cryogenic systems and products. Company OO's high power laser array transmitters are utilized on the next generation of military and commercial satellites for communications.

DOD KEY TECHNOLOGY AREAS: Sensors, Electronics

BMDO 99-005 TITLE: Non-Nuclear Power Sources and Power Conditioning

INTRODUCTION: New and unique non-nuclear power sources and new materials and electronics that provide for the efficient use of power are under consideration by BMDO for both TMD and NMD applications. New technology could conceivably provide support to future systems, which may eventually find their utilization in a ballistic missile technology program or major defense acquisition program. All areas of power technology, except nuclear power, provide potential avenues toward finding and disabling a ballistic missile in flight. BMDO SBIR shall not consider any nuclear power source proposal. Furthermore, entire power source systems, components, sub-components, and piece part specifics are constantly under evaluation by the various component TMD and NMD elements for replacement by the latest technology developments from industry.

DESCRIPTION: New technologies for providing power which provide substantial improvements in lower recurring cost, lower mass, and/or smaller size are sought for all ballistic missile defense applications. New concepts for compact power sources and power conditioning devices for transportable or mobile systems at 200 kW to 1 MW also need to have high efficiency, low signatures, and high reliability. Power generation, power storage, and power conditioning devices that operate at cryogenic temperatures for use in a new concept for all cryogenic systems are sought. Power conditioning devices of interest include, but are not limited to, capacitors, inductors, switches, and transformerless approaches. Space assets' power sources in the 0.5 to 5 kW power range, including solar arrays and their photovoltaic cells, need to tolerate high natural radiation levels. Satellite energy storage systems or novel battery technologies must provide cycle lifetimes of up to 40,000 cycles and may be utilized in low earth orbit sensor satellites, airborne platforms, or ground based assets. Onboard power sources for interceptor missiles need to be periodically testable and have a quick start-up capability. Power conditioning systems and components for space assets should provide very high efficiency

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (REAL-WORLD EXAMPLES): Company K, with a market cap of $22M+, has provided for commercializing its self-restoring fault current limiter after it was incorporated into military efforts. Company MM, with a market cap of $76M+, has developed new solar cells with increased efficiencies that have been utilized by both military and civilian interest.

DOD KEY TECHNOLOGY AREAS: Aerospace Propulsion and Power

BMDO 99-006 TITLE: Propulsion and Logistics Systems

INTRODUCTION: BMDO is constantly investigating various propulsion technologies for both TMD and NMD applications. Significant investments are made each year in the continued development of increasingly robust and responsive systems which may eventually find their utilization in a ballistic missile technology program or major defense acquisition programs. All areas of propulsion technology provide potential avenues toward finding and disabling a ballistic missile in flight. Furthermore, entire propulsion systems, components, sub-components, and piece part specifics are constantly under evaluation by the various TMD and NMD elements for replacement by the latest technology developments from industry.

DESCRIPTION: In general, missile defense places unprecedented demands on all types of propulsion systems; interceptors, launch to low earth orbit, orbit transfer, orbit maneuvering, and station keeping. Specifically, advancements are needed to achieve major reductions in the costs of placing and maintaining payloads in desired locations. Approaches leading to techniques, methods, processes, and products in support of these propulsion and logistics objectives are sought. Propulsion approaches include liquid, solid, and electric. Advancements are needed in propulsion-related areas, e.g. extending storage time of cryogenic fluids (e.g. H2 and Xe), reduction of contamination from effluents, and sensors and controls for autonomous operation. Areas of interest include the entire spectrum of space transportation and support: efficient launch systems for small technological payloads as well as full system payloads, assembly, and control systems; expendable and recoverable components; improved structures and materials; and increased propulsion efficiency. In anticipation of solar power demonstration missions incorporating electric thrusters, BMDO seeks high power electric thruster modules (e.g., electrodes, insulators, ignition systems, propellant controls, command and control systems, thermal management systems, and power conditioning units). With the advent of small surveillance satellites, low power (0.5 to 2 kW) electric propulsion is under consideration for station keeping and orbit transfer; for such systems emphasis is being placed on achieving higher power densities for components of the integrated system (thruster, power conditioning unit, fuel control, gimbals, and fuel storage). Low mass or miniature interceptors require advances in divert (small thrusters) propulsion systems (either solid or liquid). High acceleration divert and attitude control systems greater than 10Gs are under consideration.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (REAL-WORLD EXAMPLES): Company L, with a market cap of $56M+, developed a laser radar tracking technology that finds commercial use in laser eye-surgery applications, but was also investigated for tracking ballistic missiles in flight.

DOD KEY TECHNOLOGY AREAS: Aerospace Propulsion and Power, Air Vehicles/Space Vehicles

BMDO 99-007 TITLE: Thermal Management

INTRODUCTION: BMDO constantly investigates various thermal management and cooling technologies for both TMD and NMD applications. Therefore, a significant investment is made each year in the continued development of increasingly robust and sophisticated heating/cooling system technologies, which may eventually find their utilization in a ballistic missile technology program or major defense acquisition program. Furthermore, thermal management (heating and cooling) systems, components, sub-components, and piece part specifics are constantly under evaluation by the various TMD and NMD elements for replacement by the latest technology developments from industry.

DESCRIPTION: Higher power levels of various ballistic missile defense assets must dissipate heat at state-of-the-art capabilities for waste thermal energy acquisition, transport, and dissipation to space. Technology advancements are required in thermal management for power generation systems, space platform payloads, heat pump radiators, and all associated electronics. Some space platforms will require years of storage of large amounts of cryogen with minimum cryogenic loss and high cryogen delivery rates under condition of zero-g. Concepts, devices, and advanced technologies for all types of space-based power cycles are sought which can satisfy these projected ground/air/space platform requirements.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (REAL-WORLD EXAMPLES): Currently addressing electric vehicle technology applications for military and commercial interest, Company M got its initial start, and now with a market cap of $70M+, with active magnetic vibration isolation controls funded under this topic.

DOD KEY TECHNOLOGY AREAS: Electronics, Air Vehicles/Space Vehicles

BMDO 99-008 TITLE: Survivability Technology

INTRODUCTION: Missile defense elements must operate and survive against determined attacks. Threat actions can generate a reasonable set of hostile man-made environments before and during operations. Collateral environments and natural space environments (atomic oxygen, space radiation and micrometeorites/debris) provide additional technical challenges, which also affect civilian assets. Survivability engineering technology and survivability enhancement options are required to achieve a cost-effective, yet integrated solution to a dynamic and diverse set of hostile environments with a focus toward improving aspects of threat sensing, hardening, passive defense, and camouflage, concealment and deception (CCD).

DESCRIPTION: Sensor technologies enable the defense elements to detect nuclear events, laser and radio frequency weapon attacks, and to respond appropriately. Sensor technologies that can characterize the threat according to direction of attack, and spectral characteristics are currently under consideration. Technologies to enhance passive defense missile systems, ground/air/space assets, and support equipment are needed to operate against the threat support sensors, including radar, passive visible/IR sensors and seekers, and laser radar.

Passive hardening against the nuclear, laser, RF, ballistic and debris environments is specifically needed, in addition to novel radiation hardening technologies and approaches against the natural space environments. Sensor technologies and their associated systems, communications antennas (RF and laser), attitude sensors, solar power, propulsion, structure and thermal control are all directly exposed to nuclear, laser, RF and debris in addition to the natural space environments. Materials and component designs, which are intrinsically hard to these environments, and/or protective devices are needed, specifically with dual-use commercialization applications. A key ballistic missile defense area of consideration is seeker/sensor subsystems, the components of which (baffle materials, mirrors, optics, structures, focal plane arrays, read out electronics, and processing) must survive the laser, nuclear, IR, and natural environments. Nuclear and laser hard concepts, materials, and devices for protection against unknown or agile lasers and rejection of RF energy. Structures and coatings providing appropriate thermal characteristics, stability under mechanical impulses and hardness to laser and RF radiation are needed. Processors, high-power ICs, and other electronic devices capable of operating in unique hostile environments presented by the strategic applications while retaining full functionality are desired. Long term space (commercial and government) applications are direct beneficiaries of these advanced technology developments. Countermeasures and integration of CCD technologies are particular useful to the operational forces and, in general, attempt to incorporate the latest military and commercial technologies to ensure an effective response to any advanced threat. A new class of weapons technologies are evolving incorporating non-lethal methods. These have a broad range of applications as a survivability countermeasure or must themselves be countered to assure full operability. Non-lethal technology efforts in this area have dual-use applications.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (REAL-WORLD EXAMPLES): Company N, with a market cap of $225M+, got started with its hardened electronics for military environments and civilian applications. Company O markets holographic products to the commercial market that started with rugate filters for sensor protection of military optics.

DOD KEY TECHNOLOGY AREAS: Electronics, Sensors, Surface/Under Surface/Ground Vehicles

BMDO 99-009 TITLE: Lethality and Vulnerability

INTRODUCTION: In implementing its TMD and NMD program activities, BMDO is continuing its developments of such efforts as the PATRIOT Advanced Capability-3 (PAC-3) missile system which has four major systems components: radar, engagement control station, launching station, and interceptors. The Navy Area Wide system will develop a sea-based capability that builds upon the existing AEGIS/Standard Missile air defense system. This system is based on the AEGIS-class cruisers and destroyers, which provide all elements of missile defense and are particularly suited to protecting forces moving inland from the sea. The Theater High-Altitude Area Defense System (THAAD) system will form the largest umbrella of missile protection in a specific theater, arching over all other missile defense systems. THAAD consists of four major systems components: truck-mounted launchers; interceptors; radar system; and battle management, command, control, communications, and intelligence (BMC3I). These increasingly sophisticated systems will provide the opportunity to destroy short and medium range ballistic missiles and other threats in the atmosphere far enough away that falling debris will not endanger friendly forces. The various BMDO technology and acquisition programs, in support of the TMD and NMD missions, are continually evaluating the latest advanced technology developments from industry as potential replacements for the current state-of-the-art sensor systems, components, sub-components, or piece part specifics.

DESCRIPTION: A major factor in determining the effectiveness of a ballistic missile defense is the lethality of the directed energy and/or kinetic energy devices used against responsively hardened targets, bulk powder, and submunition targets. Battlefield by-products of post-intercept events are currently under consideration. New concepts and technologies that produce a much higher probability of hit-to-kill intercepts are required to support applications. Ground and Point-of-Intercept technologies, instrumentation, concepts, and innovative methodologies are under consideration for cost effective incorporation into BMDO lethality efforts. Additionally, novel concepts and techniques that reduce the vulnerability of ballistic missile defense systems will increase the operational confidence level of dedicated assets. Commercial applications may benefit from the incorporation of the techniques utilized in cost-reduction, measurement and diagnostics, and meteorology instrumentation packages.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (REAL-WORLD EXAMPLES): Company P was started after receiving initial funding under this topic for its solid state optical devices, which are now commercially available products.

DOD KEY TECHNOLOGY AREAS: Conventional Weapons

BMDO 99-010 TITLE: Computer Architecture, Algorithms, and Models/Simulations

INTRODUCTION: BMDO investigates various computer technologies in support of both TMD and NMD applications. As such, a significant investment is made each year in the continued development of increasingly robust and sophisticated battle management, command, control, and communications (BMC3I) systems which may eventually find their utilization in, and support of a ballistic missile technology program or major defense acquisition program. All areas of computer software development provide potential avenues toward supporting the ability of future BMDO systems to find and disabling a ballistic missile in flight. Furthermore, complete computer systems, components, sub-components, and piece part specifics are constantly under evaluation by the various TMD and NMD elements for replacement by the latest technology developments from industry.

DESCRIPTION: Missile defense systems for battle management demand order-of-magnitude advances. A system must acquire and track thousands of objects with hundreds of networked sensors and data processors, direct weaponry to intercept targets, and determine the degree of kill. Areas of specific interest include:

- New computer architectures which are robust, compact, and fault-tolerant, but allow for the extremely rapid processing of data. Architectures may be implemented by new designs or innovative applications of existing technologies, such as optical signal processing, systolic arrays, neural networks, etc.
- Very high-level language (VHLL) design for both the development and testing of extremely large software systems.
- Novel numerical algorithms for enhancing the speed of data processing for sensing, discrimination, and systems control. These may be specifically tailored to a particular task (for instance, the execution of a phase retrieval algorithm for interferometric imaging) and may include neural networks.
- Language design to develop code optimized for highly parallel processed architectures.

- Testing techniques that will provide a high level of confidence in the successful operation of concurrent, real-time, distributed large-scale software systems. Examples include sensitivity analysis, data flow testing, mutation testing, static concurrency analysis, and dependency analysis.

- Computer network and communications security. R&D for trusted computer systems in accordance with DoD 5200.28.STD, integration of COMPUSEC with COMSEC (DoD 5200.5).

- Self-adaptive processing, simulations, and unconventional computing approaches. Algorithms and architectures for advanced decision-making. Data compression and adaptive bandwidth management techniques.

- Neurocomputing and Man-Machine Interface - rule-based artificial intelligence and neural networks combined for decision making flexibility and system robustness; development of decision trees and information display for highly, automated, short response time, training adaptive high volume scenarios.

- Software architectures for embedded computer networks that especially facilitate incremental system and software integration, hardware and software maintenance, and system evolution, without significant performance degradation.

- Hardware and software self-diagnostic capabilities for monitoring the operational readiness and performance of space and ground systems incorporating embedded computer networks.

- Virtual environments to allow diverse groups to interact in real time and increasingly realistic ways over large distances which may include hostile environments definition and ground effects modeling and simulation efforts.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (REAL-WORLD EXAMPLES): Company Q, with commercial and military sales of its automatic parallelization tool for sequential programs, marketed as *INSURE++* and *CodeWizard for Java*, is in excess of $10M/year.

DOD KEY TECHNOLOGY AREAS: Battlespace Environments, Computing and Software, Human Systems Interface, Manpower, Personnel and Training, Modeling and Simulation

BMDO 99-011 TITLE: Optical Computing and Optical Signal Processing

INTRODUCTION: In implementing its TMD and NMD program activities, BMDO is continuing its developments of such efforts as the PATRIOT Advanced Capability-3 (PAC-3) missile system which has four major systems components: radar, engagement control station, launching station, and interceptors. The Navy Area Wide system will develop a sea-based capability that builds upon the existing AEGIS/Standard Missile air defense system. This system is based on the AEGIS-class cruisers and destroyers, which provide all elements of missile defense and are particularly suited to protecting forces moving inland from the sea. The Theater High-Altitude Area Defense System (THAAD) system will form the largest umbrella of missile protection in a specific theater, arching over all other missile defense systems. THAAD consists of four major systems components: truck-mounted launchers; interceptors; radar system; and battle management, command, control, communications, and intelligence (BMC3I). These increasingly sophisticated systems will provide the opportunity to destroy short and medium range ballistic missiles and other threats in the atmosphere far enough away that falling debris will not endanger friendly forces. The various BMDO technology and acquisition programs, in support of the TMD and NMD missions, are continually evaluating the latest advanced technology developments from industry as potential replacements for the current state-of-the-art sensor systems, components, sub-components, or piece part specifics.

DESCRIPTION: Dense computing capability is sought in all architectural variations, from all optic to hybrid computers. Specific examples of areas to be addressed include, but are not limited to, high speed multiplexing, monolithic optoelectronic transmitters, holographic methods, reconfigurable interconnects, optoelectronic circuits, and any other technology contributing to advances in intra-computer communications, optical logic gates, bistable memories, optical transistors, and power limiters. Non-linear optical materials advancements and new bistable optical device configurations.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (REAL-WORLD EXAMPLES): Company R took a unique technology approach in addressing fiber-optic and other optical communications applications to both the military and commercial industry. Company S is providing a low-loss electro-optical switching array, Company T is providing optical bus extenders and fiber-optic modulators, Company U has funded technology which utilized wavelength division multiplexing techniques; all three support the ever growing optical communication industry.

DOD KEY TECHNOLOGY AREAS: Command, Control and Communications, Computing and Software, Electronics

BMDO 99-012 TITLE: Structural Concepts and Components

INTRODUCTION: The tremendous explosion in the commercial industry to develop innovative structural components has sustained BMDO investigations into various technologies in support of both TMD and NMD applications. As such, a significant investment is made each year in the continued development of increasingly robust and viable concepts which may produce technologies that eventually find their utilization in, and support of, a ballistic missile technology program or major defense acquisition program. All considered technologies provide potential avenues toward supporting the ability of future BMDO systems to address vibrations and structural integrity more efficiently than current methods will allow. Furthermore, components, sub-components, and piece part specifics are constantly under evaluation by the various TMD and NMD elements for replacement by the latest technology developments from industry.

DESCRIPTION: Minimum weight structures are needed in ballistic missile defense applications to withstand high-g loading, acoustic and thermal environments of ground based interceptors, and to provide solid bases for space systems pointing and tracking. Such structures will benefit from: (1) innovative vibration control techniques, (2) innovative fabrication approaches to cut structure cost, (3) innovative use of advanced materials and/or design approaches to minimize structure weight, and (4) innovative rapid prototyping techniques. For instance, techniques and experimental verification are needed for active and/or passive methods to measure and control vibrations caused by thermo-mechanical flutter, thruster firing, or structure borne noise caused by on-board mechanisms. "Active" structural elements containing materials and electronics to provide predictable mechanical displacement in response to applied electrical signals are of interest. Maximization of displacement, mechanical strength, and reliability; parameter stability over extended temperature ranges; and minimization of driving voltage, power, and weight of these elements are desired. Producibility improvements for curved actuator elements, flextensional, and other integrated motion amplifiers are of interest. Fabrication approaches that provide minimum weight with reduced assembly, inspection, and scrap rates for conventional, advanced composite, and "active" structures are needed to reduce costs. Of course, novel designs and material usage to reduce structure weight, while maintaining or increasing capability, are always desirable goals.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (REAL-WORLD EXAMPLES): Company V took its ultrasonic motor technology to the commercial industry and that motor can now be found in assorted novelty and gift items. Company W, with a very accurate and precise gimbal for military laser communications, also has sales to the commercial optical industry.

DOD KEY TECHNOLOGY AREAS: Material, Processes and Structures, Manufacturing Sciences and Technology

BMDO 99-013 TITLE: Structural Materials and Composites

INTRODUCTION: The commercial industry has made advances in the development of stronger, lighter, and cheaper materials for use in structural applications. BMDO investigates various composites technologies for both TMD and NMD missile applications. Furthermore, a significant investment is made each year in the continued development of increasingly viable technologies which may eventually find their utilization by a ballistic missile technology program or major defense acquisition program. All areas of composites development potentially support BMDO and its next generation of TMD and NMD systems. Furthermore, new structural materials and composites and the associated components, sub-components, and piece part specifics are constantly under evaluation by the various TMD and NMD elements for replacement by the latest technology developments from industry.

DESCRIPTION: Many of the anticipated structural advances sought will depend on major improvements in materials properties and cost effectiveness. Space structures supporting seekers and antenna must accommodate retargeting maneuvers without detrimental jitter from vibrations and thermo-mechanical flutter. Surface launched interceptors must withstand high-g loads, aerothermal heating, and structural vibration without compromising tracking accuracy. Lightweight materials are very beneficial for both ground and space based systems. Specific goals require advanced techniques and processes that include imparting oxidation resistance and damage tolerance to composites and creating high elastic modulus composites for use over a broad range of temperatures. The following are specifically sought: (1) innovative manufacturing methods for producing high modulus, fiber-reinforced glass, light metal (i.e. aluminum or magnesium), or resin matrix composites; (2) innovative procedures for the production of instrumentation, sensors, and software for on-line process monitoring and evaluation of high modulus, fiber-reinforced composites during fabrication; (3) novel approaches to tailor fiber/matrix interfaces to maximize capability in advanced composites; (4) novel methods to cut fabrication cost of metallic and/or composite spacecraft and interceptor structures; (5) innovative tooling techniques for near-net shape production of advanced composites; (6) novel low-to-no outgassing joining/bonding techniques for advanced composites; (7) innovative surface modifications to promote wear resistance; (8) new methods for integrating instrumentation (e.g., embedded sensors) into advanced composite materials and structures; and (9) novel instrumentation for determination and telemetry of material properties and data from space. Advances are also sought in materials for optical system components, mechanical moving assemblies, and protective coatings.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (REAL-WORLD EXAMPLES): Company X licensed the technology which produced commercial sales in excess of $100M for its solid lubricants for space structures for both military and civilian applications. Company PP performed so well with their technology that a Fortune 500 business completely bought it and it now operates as an independent division based on its silicon carbide optical surfacing process sponsored under this topic.

DOD KEY TECHNOLOGY AREAS: Materials, Process and Structures, Manufacturing Sciences and Technology

BMDO 99-014 TITLE: Electronic Materials

INTRODUCTION: In implementing its TMD and NMD program activities, BMDO is continuing its developments of such efforts as the PATRIOT Advanced Capability-3 (PAC-3) missile system which has four major systems components: radar, engagement control station, launching station, and interceptors. The Navy Area Wide system will develop a sea-based capability that builds upon the existing AEGIS/Standard Missile air defense system. This system is based on the AEGIS-class cruisers and destroyers, which provide all elements of missile defense and are particularly suited to protecting forces moving inland from the sea. The Theater High-Altitude Area Defense System (THAAD) system will form the largest umbrella of missile protection in a specific theater, arching over all other missile defense systems. THAAD consists of four major systems components: truck-mounted launchers; interceptors; radar system; and battle management, command, control, communications, and intelligence (BMC3I). These increasingly sophisticated systems will provide the opportunity to destroy short and medium range ballistic missiles and other threats in the atmosphere far enough away that falling debris will not endanger friendly forces. The various BMDO technology and acquisition programs, in support of the TMD and NMD missions, are continually evaluating the latest advanced technology developments from industry as potential replacements for the current state-of-the-art sensor systems, components, sub-components, or piece part specifics.

DESCRIPTION: The necessary advances in electronics for the many ballistic missile defense applications will require advances in electronics materials. Primary emphasis lies in advancing the capability of integrated circuits, detectors, sensors, large-scale integration, radiation hardness, and all electronic components. Novel quantum-well/superlattice structures that allow the realization of unique elective properties through "band gap engineering" are sought, as are new organic and polymer materials with unique electronic characteristics. In addition, exploitation of the unusual electronic properties of gallium nitride is of considerable interest. Specifically, under high speed switching conditions at >10GHz and/or cryogenic temperatures. Among the many BMDO electronic needs and interest are advances in high frequency transistor structures, solid state lasers, optical detectors, low dielectric constant packaging materials, tailored thermal conductivity, microstructural waveguides, multilayer capacitors, single-electron transistors, metallization methods for repair of conducting paths in polyceramic systems, and sol-gel processing for packaging materials.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (REAL-WORLD EXAMPLES): Company Y, with a market cap of $359M+, commercialized technology that allowed for the delivery of ultra-pure materials to semiconductor thin film reactors. Company Z, with a market cap of $12M+, manufactures radiation detection devices and was funded for avalanche photodiode arrays. Company AA, with a market cap of $112M+, has a substantial market share of the atomic layer epitaxy growth method of semiconductor compound materials based on efforts funded under this topic. Company BB, with a market cap of $244M+, which manufactures flat panel display devices, received some initial funding for their silicon-on-insulator films and organometallic chemical vapor deposition technology developments. Company CC, with a market cap of $222M+, commercialized technology based on degradation resistant laser diodes. Company DD, with a market cap of $10M+, is commercializing technology based on its surge suppression devices and marketed as SurgX. Company EE, with a market cap of $357M+, had initial funding for its high bandgap compounds and laser diode products to develop a number of commercial and military products, and has graduated from small business status. Company KK established a multilayer coating technology that can be easily transported to any location for application. Company FF developed a magnetoresistive non-volatile random access memory chip, which is also radiation hardened, and is utilized in a number of space applications for the military and commercial sectors. Company LL, with a market cap of $47M+, was started with their first Phase I from this topic and the products are used in electronics, structural ceramics, composites, cosmetics and skin care, and as industrial catalysts. Company NN, with a market cap of $228M+, is leveraging technology developed under this topic for the efficient production of semiconductors from waste recovery during the manufacturing process.

DOD KEY TECHNOLOGY AREAS: Air Vehicles/Space Vehicles, Electronics, Electronic Warfare/Directed Energy Weapons, Materials, Processes and Structures, Sensors, Surface/Under Surface/Ground Vehicles

BMDO 99-015 TITLE: Superconductivity Concepts and Materials

INTRODUCTION: New developments in industry support the viability of using superconductivity in novel ways. BMDO investigates various superconducting technologies for both TMD and NMD applications. Furthermore, a significant investment is made each year in the continued development of efforts which may eventually find that their utilization of superconductive technologies support a ballistic missile technology program or major defense acquisition program. All areas of superconductivity research provide potential avenues toward supporting further research with the goal of finding and disabling a ballistic missile in flight. Furthermore, superconductive components, sub-components, and piece part specifics are constantly under evaluation by the various TMD and NMD elements and program offices for replacement by the latest technology developments from industry.

DESCRIPTION: BMDO is interested in demonstrating both high temperature superconductor (HTS) and low temperature superconductor (LTS) devices to enable or improve strategic defenses. Emphasis in HTS technology focused toward components integrated with state-of-the-art cryoelectronics for communications systems at K- and S-bands and radar systems in the X-band power and inductive energy storage are of specific ballistic missile defense interest. The demonstration of HTS materials toward limited detection of radiation in the optical, IR, MWIR, and LWIR bands as well as for signal processing applications is also of interest. The emphasis in LTS technology is in the development and demonstration of high sensitivity detectors, digital electronics, and memory enabling on-focal plane array signal processing and operating at temperatures greater than 10K. Efforts should address packaging and interface issues and systems integration with cryocoolers and stored cryogens.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (REAL-WORLD EXAMPLES): Company GG, with a market cap of $46M+, fabricates optical components for industrial and military applications finds traceability back to superconducting detectors funded under this topic. Company HH, with a market cap of $28M+, demonstrated success from its technology based on multi-GHz superconducting shift registers.

DOD KEY TECHNOLOGY AREAS: Electronics, Sensors

BMDO 99-016 TITLE: Surprises and Opportunities

INTRODUCTION: BMDO increasingly depends on advanced technology developments, of all kinds, to invigorate its ability to find and disable missiles in flight and to defend against an increasingly sophisticated threat, to include cruise missiles. Therefore, the continued availability of emerging technology has become a vital part of the BMDO mission. BMDO has interest and investments in specific technology programs that pursue speculative, high-risk technologies that could spur a revolutionary leap or enhancements in either Theater Missile Defense or National Missile Defense capabilities. Specific goals include, but are not limited to, quickening the pace of technology and innovation developments and decreasing the time required to transform scientific breakthroughs into actual applications.

DESCRIPTION: Since ballistic missile defense is an exploration at technology's leading edge to begin with, it recognizes that surprises and opportunities may arise from creative and innovative minds in a variety of technology sectors. BMDO will consider proposals in other technologies where they present a completely unique and unusual opportunity for ballistic missile defense applications. The proposing company should take special care to describe the specific technology in complete detail and specify why ballistic missile defense applications would benefit from exploring its unique and novel implications. Proposing companies should make particular note that proposals in this topic will receive preliminary screening at BMDO and that they may be rejected as too far afield without the benefit of a full technical review received by proposals in the topics already listed. It is recommended that the proposing company focuses their submission toward one of the specific outlined topics above unless the technology proposed is truly an unquestionable innovation. This full and open call is for new/novel/innovative/unique advanced technology developments, and not for the recycling of old ideas, incremental advancements, or questionable improvements.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (REAL-WORLD EXAMPLES): Company JJ, with a market cap of $1.1B+ (The largest of any BMDO SBIR recipient and the first DoD SBIR publicly traded company to cross the $1 Billion threshold!), was funded for technology to further its intelligent client-server software solutions for mission-critical decision applications in real-time military and commercial environments.

DOD KEY TECHNOLOGY AREAS: Any potential new development may address any DoD Critical Technology Area from this topic, provided it supports BMDO mission interest at some level.

DEFENSE THREAT REDUCTION AGENCY

The Defense Threat Reduction Agency (DTRA) is seeking small businesses with a strong research and development capability and experience in weapons effects, phenomenology, operations and counterproliferation. (Please note, DTRA is not interest in weapon development, design or manufacture.) DTRA invites small businesses to send proposals to the following address:

Defense Threat Reduction Agency
ATTN: AM/SBIR
45045 Aviation Drive
Dulles, VA 20166-7517

The proposals will be processed and distributed to the appropriate technical offices for evaluation. Questions concerning the administration of the SBIR program and proposal preparation should be directed to:

Defense Threat Reduction Agency
ATTN: AM/SADBU, Mr. Bill Burks
6801 Telegraph Road
Alexandria, VA 22310-3398
Tel: (703) 325-5021
E-mail: Billy.Burks@hq.dswa.mil

DTRA has identified 17 technical topics numbered DTRA 99-001 through DTRA 99-017. These are the only topics for which proposals will be accepted. The current topics and topic descriptions are included below. These topics were initiated by the DTRA technical offices which manage the research and development in these areas. Several of the topics are intentionally broad to ensure any innovative idea which fits within DTRA's mission may be submitted. Proposals do not need to cover all aspects of these broad topics. Questions concerning the topics should be submitted to:

Defense Threat Reduction Agency
45045 Aviation Drive
Dulles, VA 20166-7517
Tel: (703) 325-6475
E-mail: ronald.yoho@hq.dswa.mil

DTRA selects proposals for funding based on the technical merit, criticality of the research, and the evaluation criteria contained in this solicitation document. As funding is limited, DTRA reserves the right to select and fund only those proposals considered to be superior in overall technical quality and filling the most critical requirements. As a result, DTRA may fund more than one proposal under a specific topic or it may fund no proposals in a topic area. Proposals which cover more than one DTRA topic should only be submitted once.

While funds have not specifically been set aside for bridge funding between Phase I and Phase II successful proposals, the potential offeror is advised to read carefully the conditions set out in this solicitation for FAST TRACK Phase II awards. Gap funding will not be considered for other Phase II awards.

DEFENSE THREAT REDUCTION AGENCY
FY 1999 SBIR TOPIC INDEX

Subject Index for the DTRA SBIR Solicitation

DEFENSE THREAT REDUCTION AGENCY
FY 1999 SBIR TOPIC DESCRIPTIONS

DTRA 99-001 TITLE: Radiation Hardened Optics

KEY TECHNOLOGY AREA: Materials/Optics

OBJECTIVE: DoD needs innovative sensors that integrate optical and electrical components to mitigate laser and nuclear effects without degrading sensor performance.

DESCRIPTION: Many optical systems require both laser and radiation hardening. Low temperature filter coatings can be applied to operating focal plane arrays, to reduce the threat of dazzle and provide radiation hardening while maintaining the sensor performance. Innovative and testable coatings are possible today.

PHASE I: Develop a methodology for selecting low temperature coatings that can be applied directly to a functional focal plane array. Demonstrate required material properties (band pass filter, reduced defect formation, yield and stress measurements). Provide a test plan that can demonstrate laser dazzle reduction and radiation hardness to cold and hot x-rays of the smart sensor.

PHASE II: Fabricate the coating over an existing calibrated sensor. Develop in-situ testing required to verify improved characterization of the coated sensors. Develop a model for the threshold or on-set of radiation effects. Provide test data to validate theoretical model from at least two simulators while tracking a blackbody target and exposed to Nd:YAG laser.

PHASE III DUAL USE APPLICATIONS: Smart optic applications can be used for various space platforms for monitoring solar flares and environmental problems.

KEYWORDS: Radiation/Laser Hardened Optical filters, X-ray/laser hardened optical materials

REFERENCES: Rugates

DTRA 99-002 TITLE: Magnetic Flyer Plate Technology

KEY TECHNOLOGY AREA: Nuclear, Chemical and Biological Defense

OBJECTIVE: Develop innovative technologies for advancing the state of the art in nuclear survivability testing for full scale reentry bodies or components subjected to the cold x-ray threat and resulting shock/impulsive loading using magnetic flyer plates.

DESCRIPTION: The DTRA Magnetic Flyer Plate facility performs subscale to fullscale testing to provide dynamic mechanical loads (in the kilobar range) of specified uniformity and planarity for various geometrical shapes. The quality of testing could be enhanced in several areas: pulse power technology as related to faster crowbar systems; improving reproducabilty of flyerplate planarity; developing fieldable flyer plate systems insensitive to tolerances of 0.001 inches; developing an aft end testing capability; developing a capability to monitor flyerplate velocities over a large area versus discrete points.

PHASE I: build a prototype instrument or system to demonstrate its performance and potential enhancing full scale testing. The prototype could be demonstrated using the DTRA Magnetic Flyer Plate facility.

PHASE II: design build and test a full scale instrument or system, and integrate with the existing DTRA facility. This may involve coordination with DTRA to schedule testing in the simulator.

PHASE III DUAL USE APPLICATIONS: In addition to the applications cited for advancing the state of the art in impact testing the technologies could be used for commercial subscale impulsive loading, blasting, structural integrity studies, and material model development.

REFERENCES:
(1) Glasstone and Dolan, The Effects of Nuclear Weapons, 1977
(2) DNA EM-1, Capabilities of Nuclear Weapons

KEYWORDS: Impact testing, Pulse Power, Shock, X-Rays, Penetration Mechanics, Capacitors, Velocity measurements, Dielectrics, Impulsive loading, TOA, Flyer Plate, Diagnostics, Electromagnetic Pulse, Nuclear Weapons Effects.

DTRA99-003 TITLE: Electromagnetic (EM) Hardening Technology Development

KEY TECHNOLOGY AREA: Electromagnetic (EM) Hardening Technologies

OBJECTIVES: Develop and demonstrate innovative and affordable electromagnetic hardening technologies and methodologies for integrated protection of military systems and COTS equipment with emphasis on mitigating high altitude electromagnetic pulse (HEMP) and high power microwave (HPM) effects. Technologies that are integral to a balanced system hardening approach (e.g., cost, performance, weight, and life cycle) are desirable.

DESCRIPTION: The Department of Defense has a requirement to ensure survivability of key military C3 and weapons systems against the effects of HEMP and emerging RF weapons threats. SECDEF has initiated a mandate to transition a 25% COTS/75% MILSPEC equipment ratio in military systems to 75% COTS/25% MILSPEC. At the same time, budgets for military procurements are undergoing drastic reductions. A key challenge is to ensure that this COTS equipment is survivable to the wide range of existing and emerging battlefield EM environments.

The following characteristics of EM hardening technologies for military systems and COTS applications are most desirable: (1) lightweight, high performance shields and protective devices; (2) integrated EM design, protection, and test techniques; (3) affordability; (4) efficient test methods; (5) field expedient hardening and testing techniques; (6) very low maintenance protective devices (e.g., transparent to user). The technology development process for this solicitation is divided into 3 phases as shown below.

PHASE I: Demonstrate the feasibility of the proposed technology or integrated technologies by deriving an approach and generating a preliminary design.

PHASE II: Resolve remaining technical issues and optimize design parameters. Demonstrate proposed technology through prototype testing. Provide detailed design and manufacturing specifications.

PHASE III DUAL USE APPLICATIONS. These electromagnetic hardening technologies are essential to effective protection of military systems. They will also prove useful in many commercial shielding and EM interference applications, especially those involving COTS equipment.

KEYWORDS: Balanced EM hardening, integrated protection, COTS hardening

DTRA99-004 TITLE: Radiation Tolerant Microelectronics and Photonics Technology Development

KEY TECHNOLOGY AREA: Radiation tolerant semiconductor technology

OBJECTIVE: The objectives of this program are to develop and demonstrate:
(1) technology to support the fabrication of radiation tolerant microelectronics and photonic devices and semiconductor materials (e.g. silicon-on-insulator material, etc.); (2) radiation hardness assurance methods and technology; (3) diagnostics to characterize the radiation response and sensitivity to radiation effects of semiconductor materials and devices; (4) electronic design automation (EDA) methods to design radiation effects in semiconductor devices and materials and; (5) unique semiconductor structures and materials capable of providing enhanced radiation and electrical performance (e.g., Tbit data transmission and storage, etc.).

DESCRIPTION: High performance, affordable and radiation tolerant microelectronics and photonics are required to support a wide variety of DoD and commercial missile and spacecraft applications. The availability of advanced semiconductor technology is critical to both defense and economic security of the US. There is a critical need for very high throughout microprocessors, large storage devices, reconfigurable logic circuits, wideband data transmission devices, multiwavelength sensors, etc. for advanced systems such as Space Based Laser, Space Based Radar and on the scientific side the upcoming Hubble replacement. Thus, we are looking for innovative solutions to ensure the availability of these and other advanced semiconductor technologies to meet the stringent performance, power, weight, reliability and radiation requirements of the above mentioned and other DoD and other government organizations systems.

PHASE III DUAL USE APPLICATIONS: The microelectronics, photonics and semiconductor material technology that will be developed under this program is applicable to military, scientific and commercial spacecraft. Radiation tolerant technology is required to meet the stringent requirements of the natural space environment as well as environments that might be engendered by nuclear weapon effects. Moreover, modern commercial spacecraft also have very stressing power, weight, reliability and performance needs.

KEYWORDS: radiation tolerant microelectronics, radiation hardened microelectronics, radiation tolerant photonics, radiation hardened photonics, radiation hardness assurance

DTRA 99-005 TITLE: Atmospheric Nuclear Effects Modeling

KEY TECHNOLOGY AREA: Modeling and Simulation

OBJECTIVE: Develop new and unique techniques for :

1. more rapidly predicting nuclear weapon phenomenology and/or nuclear effects/impacts on the operation of communications, radar or optical sensors or
2. derive new algorithms which will be able to more accurately describe/predict system impacts at current prediction speeds, or
3. a combination of both above.

These effects include, but are not limited to, nuclear burst phenomenology at all altitudes, the resulting impact on RF propagation on communications, radar and C3I operations and induced optical background impacts on optical sensors from UV through LWIR.

DESCRIPTION: Research on nuclear explosion induced phenomenology in the earth's atmosphere has a long history dating back to the Manhattan Project in the 1940's. In general the scope and detail of our predictive capability has been limited by basic knowledge, limited test data and computational facility. Over the last 40 years we have gained extensive knowledge in the areas of physics, chemistry and mathematical techniques and we have seen a tremendous increase in computational capability. (Current PC capability has outstripped the CRAY 1 of 15 years ago.) Despite the current computer power available, current computer models still make compromises when investigating nuclear phenomenology development and system impact. We still don't have complete knowledge of all the pertinent effects. Current models stress either very fast computational time for real time modeling or very detailed analyses in specific areas.

We are looking for new methods for computing nuclear burst phenomenology and nuclear burst effects on system elements and/or on combined elements. These methods may trade predictive accuracy for computational speed, but both accuracy plus speed are the ultimate desire. These methods may entail unusual ways of determining the required data or ways of more rapidly processing already calculated and stored results.

PHASE III DUAL USE APPLICATIONS: Some of the calculation tools previously started on SBIR funds have been applied to complex modeling and analysis of satellite communication. Similar techniques might be applicable to radar and optical systems design and evaluation in a naturally occurring environment as well as in the nuclear arena.

REFERENCES: Pertinent documentation in this area is either classified or has distribution limitations. Interested parties can contact the POC for specific data or references consistent with their need to know and/or contractor status.

KEYWORD: nuclear, rf, satellite communications, phenomenology, optical systems, radar

DTRA 99-006 TITLE: Smart Archive Search and Presentation Tools

CATEGORY: Applied Research, Computing and Software (intelligent systems, user interface)

OBJECTIVE: Research and Develop innovative new technologies for the intelligent search, presentation, relating and display of data and objects within the DTRA DARE digital archive.

DESCRIPTION: DTRA is currently archiving its comprehensive collection of unique and irreplaceable nuclear weapon effects information in the Data Archival and Retrieval Enhancement (DARE) system. This legacy information takes such varied forms as reports/documents, photographs, film, waveforms, tables and diagrams. Data is currently searched and accessed using Internet search technology and displayed through a web-browser interface. While there are a plethora of Internet search engines and related knowledge and display tools, few deal very effectively with the broad range of data types present in DARE, nor do they generally provide interfaces or plug-ins for on-line analysis capability or Thesauri. The objective of the research effort will be to provide innovative solutions to improving the search, analysis and display capabilities of DARE, especially in improving the system search capability across all data types and integrating data analysis tools into the system. In the post-Cold War environment with no new data from nuclear testing expected and nuclear data experts rapidly retiring, the ability to use DARE to rapidly find, effectively and intuitively display, correlate and analyze this material, particularly the numeric data, is increasingly crucial to future research efforts which rely heavily on simulations and high fidelity calculations coupled with correlation with the archived data.

PHASE I: demonstrate the proposed concept and the feasibility of incorporating the proposed technology into DARE through a working prototype or mock-up. A Phase II implementation plan should be provided.

PHASE II: develop the proposed technology and assist the developer with implementing the technology into DARE's search and navigation mechanisms.

PHASE III DUAL USE APPLICATIONS: Improved archive search technologies apply directly to a large and fast growing civilian market involving digitized workflow, data archiving and data mining technologies. A possible follow-on would be to adapt the technology to access remote databases and archives.

KEYWORDS: Digital Archive, expert systems, expert interface, intelligent queries, natural language, knowledge navigation, data archival and retrieval.

DTRA 99-007 TITLE: Automated data capture and metadata creation for a digital data archive

CATEGORY: Applied Research, Computing and Software (software and systems development)

OBJECTIVE: Explore and develop innovative, automated and low-cost methods for the digital capture and creation of associated metadata for a data archive.

DESCRIPTION: The digital capture and storage of documents into the Defense Threat Reduction Agency's data archival system has proven to be slower and more costly than anticipated. In particular, the creation of metadata labels for the digitally captured documents and material, a manual and time intensive process, has limited archive population. While information for label creation is available from different digital sources such as the agency's STILAS database, data integrity issues have limited implementation of this information into metadata labels.

PHASE I: research will demonstrate the feasibility of an automated method for creation of archive metadata labels which significantly improves the rate of metadata label production.

PHASE II: implement the developed technology and procedures into the DTRA's data archiving effort.

PHASE III DUAL USE APPLICATIONS: Suggested research is applicable to many current data transfer problems in both government and civilian sectors such as transferring data between dissimilar databases and tools for linking remote archives with different metadata.

KEYWORDS: Digital Archive, metadata, data capture and storage, data archival and retrieval, scanning.

DTRA 99-008 TITLE: Use Of Digital Video For Archiving Technical Information

CATEGORY: Applied Research, Computing and Software (software and systems development, user interface)

OBJECTIVE: Explore and develop innovative methods for storing, retrieving, displaying and transferring digital video for use in DTRA's digital archive program.

DESCRIPTION: As part of its stewardship program, the Defense Threat Reduction Agency is involved in the digital archival of video. This effort includes capturing legacy film, but also includes the videotaping of experts involved in technical discussions germane to Nuclear Weapons Effects research. Storing digitized video, searching and analyzing the subject film and associated audio and transferring these typically large files are challenging research areas which offer a large return in the capability of data archival systems to maintain useful video collections.

PHASE I: research will demonstrate the feasibility of a proposed technology to improve digital video archiving.

PHASE II: implement the developed technology and procedures into the DTRA's data archive system.

PHASE III DUAL USE APPLICATIONS: Suggested research is applicable to many current data transfer and archival problems in both government and civilian sectors. Follow on applications might include x-ray diagnosis/analysis tools and smart military imagery analysis tools for targeting.

KEYWORDS: Digital Video Archive, data streaming, video compression, video search.

DTRA 99-009 TITLE: Nuclear Weapons System and WMD Demilitarization Safety Assessments/Special Studies

KEY TECHNOLOGY AREA: Exploratory Development, Safety

OBJECTIVE: Improved safety of US nuclear weapons systems and WMD demilitarization operations.

DESCRIPTION: Quantifying, reducing, and managing the risks associated with the life-cycle management of military nuclear weapons systems and weapon demilitarization is of vital importance. New and innovative concepts to improve on traditional probabilistic risk assessment techniques and methodologies, as well as operations are desired to increase the overall safety of these assets. Abnormal environments that these systems may encounter include mechanical insults (e.g., drops, vehicle accidents), thermal insults (e.g., fuel fires), electrical insults (e.g., lightning, electrical power), and combinations of these environments. Long range program thrusts include characterizing these abnormal environments, analyzing human factors and developing quick running models to allow decision makers to manage safety risks. Concepts should employ innovative ideas and make use of new and emerging technologies. Work will include measuring risk improvements, risk reduction techniques, and advanced algorithms for improved quick-look capabilities. Measures to improve the safety of nuclear weapons systems and demilitarization operations against all possible abnormal environments are required. Safety enhancement measures include prediction of the likelihood of adverse events through characterization of initiators and eliminating/mitigating such initiators. Proposals should describe how they will improve protection against known and predicted risks and should emphasize risk elimination/reduction where appropriate.

PHASE I: demonstrate the feasibility and potential usefulness of the proposed safety technologies/techniques.

PHASE II: fully develop the proposed technologies/techniques so they can be compared to existing techniques.

PHASE III DUAL USE APPLICATIONS: Data and models from an activity such as this SBIR area have potential for adaptation to a variety of users. Risk is a common concept used in commercial activities as varied as finance and insurance to transportation networks and major engineering projects. Minimization of risk is important in many occupations, such as manufacturing. Risk models can be used in evaluating alternatives, optimizing safety budgets and equipment design, as well as reducing risks in the work place/home or comparing alternative decisions. The quantification and understanding, as well as the reduction or elimination of risks can be used to increase the continued viability of many commercial endeavors.

KEYWORDS: Safety, Risk, Nuclear Weapons, Abnormal Environments, mechanical, thermal, electrical, human factors, modeling, risk reduction, accident initiators, Probabilistic Risk Assessment, risk elimination, risk mitigation

DTRA 99-010 TITLE: CW/BW Detection Using Novel Sensor Technologies

KEY TECHNOLOGY AREAS: Primary Area is *Sensors*; Secondary area is *Chemical and Biological Defense*

OBJECTIVE: Improve/develop US technical capability to demonstrate its compliance, and verify/monitor compliance of other states, with existing and future arms control treaties and agreements including: the Chemical Weapons Convention (CWC), Bilateral Destruction Agreement (BDA), Biological Weapons Convention (BWC), and the Joint US/UK/Russian Statement on Biological Weapons.

DESCRIPTION: New verification technologies and methods will be required to accurately monitor treaty compliance. The development of chemical and biological sensors is needed to facilitate on-site sample collection and preparation, screening and analysis. Sample screening is required to identify appropriate sample collection locations that have potential for containing key target analytes in water, soil, or air matrices, and to prioritize those collected samples for further determinative analysis. Sensors will be developed to conduct simultaneous detection of multiple chemical compounds, or biological agents and toxins, in a given treaty area. Sensors will be designed to permit the identification of target molecules, biological agents, or toxins in the presence of numerous interferents. The device must be portable and rugged for on-site field use. Sensors must achieve the necessary level of specificity to eliminate false-positive responses, while achieving state-of-the-art sensitivity level (e.g., minimum of 1-10 ppm for sample screening for chemical compounds). Sensor performance will be characterized by stability, reliability, reproducibility, and usability. Sensor technologies and assays must be robust in performance and engineering.

PHASE I: Demonstrate the feasibility of the proposed technology to detect/discriminate chemicals, biological agents, biological molecules and toxins applicable to chemical and/or biological arms control treaties and agreements.

PHASE II: Develop proof of concept and reduction to practice to demonstrate the proposed technology; prototype instrument.

PHASE III: Dual Use Applications: Chemical monitoring systems; environmental on-site analysis for site remediation/hazardous waste clean-up.

REFERENCES: The following web sites may be useful in obtaining relevant background information about the CWC and BWC.

1. http://www.opcw.nl
2. http://www.acda.gov
3. http://www.osia.mil
4. http://www.dswa.mil
5. http://pmaweb.hq.dswa.mil

DTRA 99-011 TITLE: Tracking Atmospheric Plumes Based on Stand-Off Sensor Data

KEY TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop an approach to identifying and locating the source of nuclear events that generate atmospheric plumes by backtracking their atmospheric plumes.

DESCRIPTION: At present, a worldwide network of radionuclide monitoring stations with a spacing of several hundred km. is being set up to monitor radioactive fall-out from atmospheric nuclear tests under the Comprehensive Test Ban Treaty (CTBT). These stations sample the air for radioactive particulates and radioactive Xenon on a daily basis. To interpret the results, a means of estimating where any suspicious radionuclides might have originated is needed. DTRA seeks a software system that will allow an assessment of where the air parcels sampled by a monitoring station may have come from. Ideally, an accuracy of 1,000 sq. km. would be desirable. The system should take account of the properties of the radionuclides involved (e.g., settling, washout by rain, chemical reactions) as well as weather patterns. Appropriate historical data to test the system should be identified, and such a test should be part of the proposed work. Off-line analysis is envisaged, both automated or interactive systems, or both, will be considered. The system is being considered for the Prototype International Data Center (PIDC) presently being developed for the CTBT, and should be able to use the type of data being produced at the PIDC.

PHASE III DUAL USE APPLICATIONS: Atmospheric monitoring of pollutants from fixed sources, such as power plants (nuclear and non-nuclear)

KEYWORD LIST: radionuclide, atmospheric plumes, backtracking, atmospheric nuclear tests, fall-out, weather, pollutants.

DTRA 99-012 TITLE: Improved Seismic Location Procedure(s)

KEY TECHNOLOGY AREA: Computing and Software, ChemBio

OBJECTIVE: Conduct innovative research and develop new tools to locate man-made or natural seismic events using realistic (3-dimensional) velocity structure and either (1) surface sensors at near-regional or regional distances or (2) borehole sensors at local distance (i.e., within the testbed).

DESCRIPTION: Seismic location is one of the most challenging problems in monitoring a Comprehensive Test Ban (CTB). For events at low threshold, the effects due to lateral heterogeneity in the crust becomes apparent and the conventional methods of relying on a global 1-dimensional velocity model (such as J.-B. model) and exclusively teleseismic recordings may not work. As the problem shifts from teleseismic setting to a regional one, new and demanding computational requirements arise. This research initiative seeks innovative approaches that address various aspects of the seismic location problem in the CTBT era: the crustal structure is complex, 3-dimensional, the seismic network is sparse with a possibly skew configuration, need to use regional phase exclusively, etc.

PHASE I proposals should respond to at least one of the following areas:

(1) Develop innovative concepts as how to use a hypothetical 3-dimensional velocity structure and arbitrary selected hypocenter. The procedure must be capable of efficiently handling the computation of travel times to be used in the iterative inversions. Note that many published algorithms only provide the travel time for the first arrival or utilize the first arrivals in inversion. What is being sought under this initiative is a location algorithm that can fully exploit the secondary arrival picks as well, particularly at regional distances. (The development of efficient forward computation algorithm for secondary phases can be pursued as a separate research project, if appropriate.)

(2) If seismic events are clustered, then simultaneously determining the epicenters, average 1-dimensional velocity model as well as station correction (relative to the resulting 1-D model) is possible. An improved and well-tested software package would be useful whether at local, regional or global scale.

PHASE II depends on the specific subtopic the contractor chooses under the Phase I effort. The effort (product) can be one of the following: (a) a location module that can be incorporated into the data analysis system at the U.S. National Data

Center (U.S. NDC) and the International Data Center (IDC) for monitoring a CTBT, and (b) a software package that can be used in intrusive damage analysis, such as the effectiveness study of hard-target penetrator.

PHASE III - DUAL USE APPLICATIONS: Rockbust / mining collapse monitoring in underground mines, Earthquake hazards reduction, military applications (e.g., penetrator testbed).

KEYWORD LIST: location, inversion, seismic data, geophone data, environmental

DTRA 99-013 TITLE: Universal Seismic Event Discrimination System

KEY TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop a robust special event analysis subsystem for the discrimination and identification of suspicious seismic events.

DESCRIPTION: The U.S. is developing a global system for monitoring nuclear proliferation activities and for potential use in verifying compliance with a CTBT. The system will collect data from a world-wide network of seismic stations and arrays for tens of thousands of detected earthquakes and explosions per year. Some events may be suspicious due to their location and depth and will warrant further analysis and a review of the results of the automated system. This initiative seeks subsystems for special event analysis and discrimination. Key elements will include: portability and versatility; operating system platform-independent; communication software for retrieving waveform and other data over the internet; a ground truth database for waveform comparison; regional velocity models and station/source calibration tables; location codes; synthetic seismogram programs; mapping and waveform display software. These and other elements should be integrated into a single menu driven system with a user-friendly interface.

PHAE III - DUAL USE APPLICATIONS: The subsystem will be based on platform-independent software components (including a Java graphical interface), and thus be available in the more popular PC market as well as UNIX.

DTRA 99-014 TITLE: Development of Multi-dimensional Databases for Rapid Processing of CTBT Monitoring Data

KEY TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop efficient database application to improve the exploitation of very large database for monitoring the Comprehensive Test ban Treaty

DESCRIPTION: Nuclear monitoring data are currently stored in relational databases, and they are accessed and manipulated using the SQL language. This kind of database is far from efficient for performing complex operations, especially mathematical ones, on the data that are stored within them. These complex operations require an altogether different type of database that is best suited for this application. DTRA seeks to investigate whether multi-dimensional databases are better suited than are relational databases for performing the types of operations which scientists must perform routinely in order to verify compliance with a CTBT. It is hoped that the technology shall focus to expedite the mathematical analysis of the databases, so as to make it easier for scientists to exploit the contents of very large databases for nuclear monitoring tasks, such as identifying anomalous events. A multi-dimensional database shall be designed and populated with data from the relational databases at the Center for Monitoring Research utilizing a product that is compatible to the database engine currently used at the PIDC. Software applications shall be designed to conduct complex operations on the database. The utility of this technology shall be evaluated by testing its efficiency for conducting the same analyses of nuclear monitoring data as are currently performed by conducting SQL queries of the relational databases at the PIDC.

KEYWORD LIST: Database management

DTRA 99-015 TITLE: Multi-Dimensional Visualization of Data to Identify Seismic Events or for Other Complex Multi-Dimensional Data Problems

KEY TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop a visualization subsystem for the discrimination of different types of detected seismic events; test the subsystem with the Nuclear Treaty Programs Office's (NTPOs) Intelligent Monitoring System; and demonstrate the subsystem's potential application to other multi-dimensional data problems.

DESCRIPTION: DoD is developing a global system for monitoring nuclear proliferation activities and for potential use in verifying compliance with a Comprehensive Nuclear Test Ban Treaty (CTBT). The system will collect data from a worldwide network of seismic stations and arrays, as well as sensors deployed for air, particulate, and other types of environmental sampling. The seismic system alone will have to process data from several hundred monitoring stations for tens of thousands of detected earthquakes and explosions per year. Results of the final analysis must be available within 24-48 hours of the occurrence of the events. Achieving this goal within the available resources will require automatic data processing and an enhanced data interpretation capability. NTPO is exploring technologies such as machine learning, machine discovery, and visualization methods to aid in the data interpretation.

This initiative seeks subsystems implementing novel visualization techniques and components to aid in interpreting the results of multivariate seismic discrimination analysis, particularly for small seismic events detected at regional distances out to 2,000 km. The subsystems will be installed in the Intelligent Monitoring System at NTPO's Center or Monitoring Research (CMR) located in Rosslyn, Virginia, and tested with data acquired and processed by the Intelligent Monitoring System. The performer will demonstrate how the visualization techniques can be applied to the general problem of monitoring the proliferation of weapons of mass destruction by demonstrating that it is capable of aiding human analysts in interpreting data from the global seismic monitoring system.

PHASE III - DUAL USE APPLICATION: Visualization subsystem to aid in the solution of generic multi-dimensional or multivariate problems. This could include topics ranging from environmental monitoring to air traffic control.

DTRA 99-016 TITLE: Wide Area Detection (WAD) and Mapping Technologies for Locating Minefields Containing Anti-Personnel Landmines (APL)

KEY TECHNOLOGY AREA: Computing, Software, and Sensors

OBJECTIVE: Develop a US technical capability to detect and map APL minefields as part of a verification/monitoring regime of potential APL agreement/ban treaties, including Convention on Conventional Weapons (CCW) – Modified Protocol II, Ottawa Convention on APL Ban, and Conference on Disarmament (CD) Process for APL Ban.

DESCRIPTION: The US government has a long-range goal of banning use, export, stockpiling and production of all types of APL. The purpose of this ban is to reduce or eliminate post-war civilian casualties. The Defense Threat Reduction Agency (DTRA) has the responsibility to provide RDT&E support to all arms control treaties including the APL ban that is being currently pursued. As part of the APL ban treaty verification and/or monitoring requirements and the need for treaty required technical assistance toward demining, DTRA is seeking safe, cost-effective, and reliable technologies for wide area detection. DTRA has reviewed the programs of other U.S. government offices (SO/LIC, NVESD, JUXOCO as shown in the references) in the area of mine detection, and found that in these programs there is more emphasis on individual mine detection and clearance than on wide area detection and mapping of APL minefields. The DTRA effort is to detect APL minefields safely, rapidly and with high probability in order to meet future treaty mission needs. The system or technology to be developed will be used to verify a proposed ban on use of APL and for technical assistance in demining. The verification process could involve monitoring large areas of the world to validate reported APL minefield boundaries and to inspect new suspected deployments of APL as well as any expansions of existing minefields.

The potential need of DoD and DTRA regarding an APL ban treaty is to develop a proof of concept of a system to detect and map APL minefields. This total effort may be subdivided into different technology developments. The potential bidders are encouraged to offer solutions to one or more of the following technology areas:

1. One technology development area includes a stand-off sensor or combination of sensors and /or data fusion techniques to improve probability of detection of APL minefields. Key candidate sensors are likely to be ground penetrating radar (GPR), infrared line scanner (IRLS), electro-optical or electromagnetic sensor, and other sensors based on chemical technologies. An innovative approach to data fusion from multiple sensors is likely to be needed to meet desired performance levels.
2. Another area is the technology to convert the minefield boundary data to a geo-reference for generating a map useful to deminers and treaty verification inspectors.

3. The third area of technology development is the development of a suitable low-altitude aerial platform (UAV, small aircraft, helicopter, etc.) in support of wide area detection and to carry multiple sensors probably over rough and varied terrain.

The following characteristics of the wide area detection technologies for APL ban application are most likely: 1) high probability of detection of minefields containing metallic and non-metallic APLs, 2) no real time requirement of display or processing of data, 3) large area coverage, 4) cost-effective operations, and 5) no military threat during detection. The technology development for any of the three areas for this solicitation is divided into the following phases:

PHASE I: Demonstrate the feasibility of the proposed technology or combination of technologies by providing an approach and producing a preliminary design of the proposed system to assist in detection of minefields for the purpose of detecting presence or confirming absence of APLs.

PHASE II: Develop proof of concept to demonstrate the proposed technology. Install prototype device on an aerial platform to carry out demonstrations and tests over APL minefields. Submit a final prototype design of the proposed system.

PHASE III DUAL USE APPLICATIONS: Detection of unexploded ordnance (UXO) as part of military base clean-up operations in the US, in addition to treaty applications. The expected users of this technology are the US government implementers of an APL ban treaty or agreement.

REFERENCES:

1) GAO Report on UXO, Report No. 95-197, 20 Sep 1995

2) "Review & Identification of DOE Laboratory Technologies for Countermine/Unexploded Ordnance Detection" Cyrus Smith, Oak Ridge National Lab, December 2, 1996 (Re-issued on December 2, 1997).

KEYWORD LIST: Anti-Personnel Landmine (APL), APL Ban Treaty, Stand-off Detection, Minefield, Sensor, Data Fusion, Mapping

DTRA 99-017 TITLE: Unified Human Response to NBC Risk and Injury Model

KEY TECHNOLOGY AREA: Nuclear Weapons Lethality

OBJECTIVES: (1) To extend the applicability of the nuclear weapon effects-human response models that serve as the basis for US and NATO doctrine to include non-performance degrading effects. (2) To expand existing symptom-based human response models to include cognitive, combined injury, and risk-based data.

DESCRIPTION: The Defense Threat Reduction Agency is soliciting Small Business Innovative Research proposals to extend its existing symptom-based human response models to include cognitive, combined injury, and risk-based data. The existing models serve as the basis for US and NATO doctrinal estimates of operational and medical-load military casualties from general nuclear war. The SBIR proposals are requested to address the requirement to extend the models to address operational and health risks associated with potential missions in contaminated areas for other than general nuclear war. The proposed efforts will require collaborative research and coordination within the US and NATO research communities for related programs. However, the effort is specifically driven by published operational requirements. Specific topics include:

Unification of risk-based and performance-based human response models

Extension of primarily military population data to general population data

Effects of low-level protracted radiation on cognitive processes and representations suitable to estimate potential impacts or risks to operations

Combined injury (radiation and other insults)

Non-invasive verification and validation approaches

PHASE III DUAL USE APPLICATIONS: Directly translatable into the civil community for use with the FEMA-Congressional initiative for disaster resistant communities.

KEYWORD LIST: Human Response, risk-based modeling

UNITED STATES SPECIAL OPERATIONS COMMAND

Proposal Submission

The United States Operations Command's (USSOCOM) mission includes developing and acquiring unique special operations forces (SOF) equipment, material, supplies and services. Desired SOF operational characteristics for systems, equipment and supplies include: lightweight and micro-sized; reduced signature /low observable; built-in survivability; modular, rugged, reliable, maintainable and simplistic; operable in extremes temperature environments; water depth and atmosphere pressure proof; transportable by aircraft, ship and submarine, and deplorable by airdrop; LLPI/LPD jam resistant C3I, electronic warfare capable of disruption and deception; near real-time surveillance, intelligence and mission planning; highly lethal and destructive; low energy/power requirements; and compatible with conventional force systems.

USSOCOM is seeking small businesses with a strong research and development capability and an understanding of the SOF operational characteristics. The following topics represent a portion of the problems encountered by SOF in fulfilling its mission. USSOCOM invites the small business community to **send proposals (original plus 3 copies) directly to the following address**:

United States Special Operations Command
Attn: SOAL-KB/SBIR Program, Topic No. SOCOM 99-00__
7701 Tampa Point Blvd.
MacDill Air Force Base, Florida 33621-5316

Inquires of a general nature or questions concerning the administration of the SBIR program should be addressed to :

United States Special Operations Command
Attn: SOSB/ Ms. Karen L. Pera
7701 Tampa Point Blvd.
MacDill Air Force Base, Florida 33621-5316
Tel (813) 840-5514
Fax (813) 840-5481
E Mail perak@socom.mil

USSOCOM has identified these 3 technical topics for the FY 99.1 solicitation. Proposals will only be accepted for these 3 topics. Topics were initiated by the USSOCOM technical offices responsible for the research and development in these specific areas. The same office is responsible for the technical evaluation of the proposals. Proposal evaluation factors are listed below. Each proposal must address each factor in order to be considered for an award. Scientific and technical information assistance may be requested by using the DTIC SBIR Interactive Technical Information System (SITIS).

Firms are encouraged to submit a proposal with an optional task which would be performed during the period between Phase I completion and Phase II contract award. The optional task provides the opportunity to reduce the gap between Phase I and II funding. The maximum amount of SBIR funding used for an USSOCOM Phase I award is $100,000. Proposals that include the option task shall not exceed $70,000 for Phase I and $30,000 for Phase I Option. Options must be submitted with the basic Phase I proposal and will not be included in the basic Phase I proposal page limitation. The basic Phase I proposal shall be evaluated exclusive of the option task and must be proposed and priced separately. The option portion of the proposal shall not exceed 10 pages, not exceed $30,000, not exceed three months in duration, and will be evaluated using the same evaluation criteria as Phase I proposals. The transition option work shall be included as an option in the Phase I contract and evaluated for USSOCOM unilateral exercise at any time after Phase I award through the conclusion of the basic Phase I contract. The maximum time frame for a Phase I with or without option is 6 months. Exercise of any option shall be at the sole discretion of USSOCOM and shall not obligate USSOCOM to make a Phase II award.

Evaluation Criteria - Phase I & II

1) The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution.

2) The qualifications of the proposed principal/key investigators supporting staff, and consultants. Qualifications include not only the ability to perform the research and development but also the ability to commercialize the results.

3) The potential for commercial (Government or private sector) application and the benefits expected to accrue from this commercialization.

Selection of proposals for funding is based upon technical merit and the evaluation criteria included in this solicitation. As funding is limited, USSOCOM will select and fund only those proposals considered to be superior in overall technical quality and most critical. USSOCOM may fund more than one proposal in a specific topic area if the technical quality of the proposals are deemed superior, or it may fund no proposals in a topic area.

USSOCOM also encourages contractors to participate in the SBIR Fast Track program as described in the DOD 99.1 Solicitation. Proposing Options in the initial proposal will not prevent a contractor from participating in the Fast Track Program, however, the total USSOCOM funds for a Phase I, options, and the Fast Track funding will not exceed $140,000. It is anticipated the vast majority of Fast Track proposals will receive interim funding between Phases I and II, and that the percentage of Phase I Fast Track projects that are selected for Phase II awards should be significantly higher that the overall percentage of Phase I projects that are selected for Phase II.

USSOCOM offers information on the Internet about its SBIR program at http://www.socom. mil

USSOCOM
FY 99.1 SBIR TOPIC INDEX

USSOCOM

FY 99.1 TOPIC DESCRIPTIONS

SOCOM 99-001 TITLE: High Speed Composite Waterjet Propulsion Systems

TECHNOLOGY AREA: Materials, Processes and Structures

OBJECTIVE: The development and production of a domestic high efficiency, mixed flow, composite waterjets. These boat propulsion systems would represent the only mid-sized or large high speed waterjets made in America, and the only high speed waterjets available worldwide constructed of composite materials.

DESCRIPTION: Waterjets presently available worldwide are constructed of aluminum, whereas, high speed boats are generally constructed from composites. Typically, the waterjets are of aluminum construction, which imposes weight, cost, and technical problems when interfacing into the composite craft. Additionally, there are presently no domestic manufacturers of these propulsion systems for high speed water craft. Forming the inlet section (scoop injector) of the waterjet using composite material as part of the lay-up of a composite hull could significantly reduce the weight, cost, and technical difficulty of interfacing waterjets and composite craft. The use of integral composite intakes in composite vessels would eliminate mechanical fastening and structural and material discontinuities in composite hull bottoms, while offering weight and maintenance savings. There is a market, both military and commercial, for a high speed, lightweight, high efficiency, corrosion resistant propulsion system, which will offer designers and builders of high speed craft a cutting edge, domestic, non-developmental, and proven propulsion system.

PHASE I: Build and test a prototype composite jet unit and investigate the predicted impact of installation of the units on the 11 meter (m) military rigid hull inflatable boat (RIB).

PHASE II: Based on Government acceptance of the prototype design, construct and install two units in an 11M RIB test craft, and document the weight savings and performance impact. Provide a report including performance, weight, funding, maintenance, scheduling and logistical impact of the units versus the aluminum counterparts currently used.

PHASE III DUAL USE APPLICATIONS: These propulsion systems can be considered as an alternate propulsion system for composite propeller driven craft operating in the 35 to 60 knot speed range, and as an alternate for all aluminum waterjet installations. The low cost of manufacture, compared to forming or casting aluminum, and the ease of installation by molding the intakes into the hull, will reduce the price of these propulsion systems and allow pleasure craft builders to offer larger waterjet propelled craft at a competitive price to propeller systems.

SOCOM 99-002 TITLE: Advanced Technology Exposure Suit (ATES)

TECHNOLOGY AREA: Clothing, Textiles and Food

OBJECTIVE: Develop an advanced exposure suit, wetsuit, or new components for existing systems to provide military forces with a garment capable of transitioning from water/underwater environments directly into extended wear in an operational environment.

DESCRIPTION: Operations in extreme weather environments combined with water operations create a need for an advanced wetsuit-like garment system capable of extended wear in and out of the water. The system should provide environmental protection to a submerged diver for periods of up to 8 hours, and then provide environmental protection for land operations for periods of up to 5 days. The system should allow for multiple and uninterrupted transitions between land and underwater environments. The system should address total body environmental

protection, while providing for maximum body movement so as not to impede diving, swimming, and land combat operations. The system should be self-contained, and have no external power requirements.

PHASE I: Investigate and present to the Government potential materials and design concepts suitable for ATES. Based on Government guidance, design, fabricate, and conduct laboratory-scale testing of a prototype ATES.

PHASE II: Based on the Phase I results, refine and develop the final ATES design. Fabricate and test prototypes using Government provided test profiles. Following Government review and comment on the prototype design and test results, modify and refurbish test prototypes and submit to the Government for operational assessment. Make final design changes based on Government input following the operational assessment.

PHASE III DUAL USE APPLICATIONS: The ATES would have application for recreational sports enthusiasts (e.g., tri/bi-athletes, personal watercraft operators, divers, and surfers).

SOCOM 99-003 TITLE: Remote Sighting System for Weapons

TECHNOLOGY AREA: Conventional Weapons

OBJECTIVE: Develop an advanced video-based sighting system that interfaces with standard small arms to provide remote sighting capabilities for low-visibility/obstructed view targeting environments.

DESCRIPTION: The ability to sight small arms accurately in situations with obstructed views and low-visibility would significantly enhance the safety and effectiveness of ground troops. This is particularly true for urban and low-intensity situations where operation from cover or concealment markedly reduce the threat to the operator. A system is envisioned that combines video images and weapons sighting into one remote display (e.g. head mounted), and operates effectively in low-visibility conditions. Low-powered illuminator, digital sensor, display, and processing technologies are presently available to support this requirement. A system should be developed that integrates these technologies, using low-cost components, to provide the desired capability. Quick assembly, disassembly, and adaptability (i.e., mounting and sight calibration) to a variety of weapons are essential. The system must be able to withstand the rigors of combat operations, to include airdrop and diving operations to 66 feet sea water. The system should be designed in a modular and open system fashion to provide for easy upgrades as the various components are improved.

PHASE I: Design and fabricate a prototype system, and demonstrate its capabilities. It is critical here to demonstrate operational feasibility in terms of performance, power requirements, configuration, survivability, and effective interface with representative weapons and the operator.

PHASE II: Refine design using the results of the Phase I investigation, and fabricate and test prototypes. Following Government review and comment on prototype design and test results, modify and refurbish test prototypes and submit to the Government for operational assessment. Make final design changes based on Government input following operational assessment.

PHASE III DUAL USE APPLICATIONS: The remote sighting system would have application to enhance the safety and effectiveness of military operators and law enforcement personnel. Additional applications include sensing/sighting systems for robots and security systems. To increase the system's utility and applicability, it could be further designed to provide situational awareness inputs to tactical C4I elements.

9.0 SUBMISSION FORMS AND CERTIFICATIONS

Section 9.0 contains:

Appendix A: **Proposal Cover Sheet**
Appendix A (or photocopy) must be signed and included with each proposal submitted.

Appendix B: **Project Summary Form**
Appendix B (or photocopy) must be included with each proposal submitted. Don't include proprietary or classified information in the project summary form.

Appendix C: **Cost Proposal Outline**
A cost proposal following the format in Appendix C must be included with each proposal submitted.

Appendix D: **Fast Track Application Form**
A DoD pilot program under which projects that attract outside investors receive interim funding and selection for Phase II award provided they are "technically sufficient" and have substantially met Phase I goals.

Appendix E: **Company Commercialization Report**
A report that identifies each Phase II SBIR and/or STTR project your firm has received, and Phase III sales and/or funding resulting from each project. All Phase I and Phase II proposals must include a Company Commercialization Report.

Reference A: **Proposal Receipt Notification Form**

Reference B: **DTIC Information Request Form**

Reference C: **Directory of Small Business Specialists**

Reference D: **SF 298 Report Documentation Page**

Reference E: **DoD Fast Track Guidance**

Reference F: **DoD's Critical Technologies**

Reference G: **DoD SBIR/STTR Mailing List Form**

U.S. DEPARTMENT OF DEFENSE

SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
PROPOSAL COVER SHEET

Failure to fill in all appropriate
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TOPIC NUMBER: ______________________

PROPOSAL TITLE: ______________________

____

FIRM NAME: ______________________

MAIL ADDRESS: ______________________

____

CITY: ______________________ STATE: __________ ZIP: __________

PROPOSED COST: ______________________ PHASE I OR II: _____ PROPOSAL PROPOSED DURATION: _____ IN MONTHS

BUSINESS CERTIFICATION:

	YES	NO
▸ Are you a small business as described in paragraph 2.2?	☐	☐
▸ Number of employees including all affiliates (average for preceding 12 months): ______________		
▸ Are you a socially and economically disadvantaged business as defined in paragraph 2.3? (Collected for statistical purposes only)	☐	☐
▸ Are you a woman-owned small business as described in paragraph 2.4? (Collected for statistical purposes only)	☐	☐
▸ Have you submitted proposals or received awards containing a significant amount of essentially equivalent work under other DoD or federal program solicitations? If yes, list the name(s) of the agency or DoD component, submission date, and Topic Number in the spaces below.	☐	☐

______________________ ______________________

______________________ ______________________

PROJECT MANAGER/PRINCIPAL INVESTIGATOR	CORPORATE OFFICIAL (BUSINESS)
NAME: ______________________	NAME: ______________________
TITLE: ______________________	TITLE: ______________________
PH: __________ FAX: __________	PH: __________ FAX: __________

For any purpose other than to evaluate the proposal, this data except Appendix A and B shall not be disclosed outside the Government and shall not be duplicated, used or disclosed in whole or in part, provided that if a contract is awarded to this proposer as a result of or in connection with the submission of this data, the Government shall have the right to duplicate, use or disclose the data to the extent provided in the funding agreement. This restriction does not limit the Government's right to use information contained in the data if it is obtained from another source without restriction. The data subject to this restriction is contained on the pages of the proposal listed on the line below.

PROPRIETARY INFORMATION: ______________________

Before signing below, please read the cautionary note at Section 3.7

______________________	__________	______________________	__________
SIGNATURE OF PRINCIPAL INVESTIGATOR	DATE	SIGNATURE OF CORPORATE BUSINESS OFFICIAL	DATE

Nothing on this page is classified or proprietary information/data

INSTRUCTIONS FOR COMPLETING APPENDIX A

AND APPENDIX B

General:

DOD Components employ automated optical devices to record SBIR proposal information. Therefore the proposal cover sheet (Appendix A) and the project summary (Appendix B) should be typed without proportional spacing using one of the following type styles:

Courier 12,10 or 12 pitch
Courier 71 10 pitch
Elite 71
Letter Gothic 10 or 12 pitch
OCR-B 10 or 12 pitch
Pica 72 10 pitch
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U.S. DEPARTMENT OF DEFENSE

SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
PROPOSAL COVER SHEET

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PROPOSAL TITLE: ____________________

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FIRM NAME: ____________________

MAIL ADDRESS: ____________________

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CITY: ____________________ STATE: __________ ZIP: __________

PROPOSED COST: ____________________ PHASE I OR II: _____ PROPOSAL PROPOSED DURATION: _____ IN MONTHS

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____________________ ____________________

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AND APPENDIX B

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SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
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PROPOSAL COVER SHEET

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U.S. DEPARTMENT OF DEFENSE

SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
PROJECT SUMMARY

Failure to fill in all appropriate
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TOPIC NUMBER: ____________________

PROPOSAL TITLE: ____________________

____

FIRM NAME: ____________________

PHASE I or II PROPOSAL: ________

Technical Abstract (Limit your abstract to 200 words with no classified or proprietary information/data.)

Anticipated Benefits/Potential Commercial Applications of the Research or Development.

List a maximum of 8 Key Words or short (2-3 word) phrases that describe the Project.

____________________ ____________________

____________________ ____________________

____________________ ____________________

____________________ ____________________

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AND APPENDIX B

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U.S. DEPARTMENT OF DEFENSE

SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
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PHASE I or II PROPOSAL: ________

Technical Abstract (Limit your abstract to 200 words with no classified or proprietary information/data.)

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List a maximum of 8 Key Words or short (2-3 word) phrases that describe the Project.

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FIRM NAME: ______________________

PHASE I or II PROPOSAL: __________

Technical Abstract (Limit your abstract to 200 words with no classified or proprietary information/data.)

Anticipated Benefits/Potential Commercial Applications of the Research or Development.

List a maximum of 8 Key Words or short (2-3 word) phrases that describe the Project.

______________________ ______________________

______________________ ______________________

______________________ ______________________

______________________ ______________________

Nothing on this page is classified or proprietary information/data

INSTRUCTIONS FOR COMPLETING APPENDIX A

AND APPENDIX B

General:

DOD Components employ automated optical devices to record SBIR proposal information. Therefore the proposal cover sheet (Appendix A) and the project summary (Appendix B) should be typed without proportional spacing using one of the following type styles:

Courier 12,10 or 12 pitch
Courier 71 10 pitch
Elite 71
Letter Gothic 10 or 12 pitch
OCR-B 10 or 12 pitch
Pica 72 10 pitch
Prestige Elite 10 or 12 pitch
Prestige Pica 10 Pitch

Whenever a numerical value is requested type the numerical character (i.e. in "Proposed Duration" type 6 NOT six).

When typing address information use the two alphabet characters used by the Post Office for the state, DO NOT SPELL OUT THE FULL STATE NAME (i.e. type NY not New York or N.Y.).

Complete and submit the Appendix A and B forms as pages 1 and 2 of each proposal. In addition, (4) complete copies of the proposal must be submitted (see Section 6).

Carefully align the forms in the typewriter using the underlines as a guide. The forms are printed to accommodate standard typewriter spacing.

Additional forms may be downloaded from our Home Page (http://www.acq.osd.mil/sadbu/sbir). They may also be obtained from your State SBIR Organization (Reference D) or:

DoD SBIR Support Services
2850 Metro Drive, Suite 600
Minneapolis, MN 55425-1566
(800) 382-4634

U.S. DEPARTMENT OF DEFENSE

SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
PROJECT SUMMARY

Failure to fill in all appropriate
spaces may cause your proposal to be disqualified

TOPIC NUMBER: ______________________

PROPOSAL TITLE: ____

____

FIRM NAME: ____

PHASE I or II PROPOSAL: ________

Technical Abstract (Limit your abstract to 200 words with no classified or proprietary information/data.)

Anticipated Benefits/Potential Commercial Applications of the Research or Development.

List a maximum of 8 Key Words or short (2-3 word) phrases that describe the Project.

______________________ ______________________

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AND APPENDIX B

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Courier 71 10 pitch
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Letter Gothic 10 or 12 pitch
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When typing address information use the two alphabet characters used by the Post Office for the state, DO NOT SPELL OUT THE FULL STATE NAME (i.e. type NY not New York or N.Y.).

Complete and submit the Appendix A and B forms as pages 1 and 2 of each proposal. In addition, (4) complete copies of the proposal must be submitted (see Section 6).

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U.S. DEPARTMENT OF DEFENSE

SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
COST PROPOSAL

Background:

Offerors should indicate the following items, as appropriate, in their proposal, following the instructions in Section 3.4(m) of this solicitation.

Cost Breakdown Items (in this order, as appropriate):

1. Name of offeror
2. Home office address
3. Location where work will be performed
4. Title of proposed effort
5. Company's taxpayer identification number and CAGE code. *(Note: Offerors that do not yet have these items -- e.g., because the company does not yet exist at the time of proposal submission -- should so indicate in the cost proposal. Such offerors, if selected for award, should talk with their DoD contracting officer about obtaining these items, both of which are required before a contract can be awarded.)*
6. Topic number and topic title from DoD Solicitation Brochure
7. Total dollar amount of the proposal
8. Direct material costs
   a. Purchased parts (dollars)
   b. Subcontracted items (dollars)
   c. Other
      (1) Raw material (dollars)
      (2) Your standard commercial items (dollars)
      (3) Interdivisional transfers (at other than cost dollars)
   d. Total direct material (dollars)
9. Material overhead (rate_____%) x total direct material = dollars
10. Direct labor (specify)
    a. Type of labor, estimated hours, rate per hour and dollar cost for each type (e.g., "computer programmer, 40 hours, $26 per hour, $1040 cost"). Include the name as well as the hours, etc. of all key personnel.
    b. Total estimated direct labor (dollars)
11. Labor overhead
    a. Identify overhead rate, the hour base and dollar cost
    b. Total estimated labor overhead (dollars)
12. Special testing (include field work at government installations)
    a. Provide dollar cost for each item of special testing
    b. Estimated total special testing (dollars)
13. Special equipment
    a. If direct charge, specify each item and cost of each
    b. Estimated total special equipment (dollars)
14. Travel (if direct charge)
    a. Transportation (detailed breakdown and dollars)
    b. Per diem or subsistence (details and dollars)
    c. Estimated total travel (dollars)
15. Subcontracts (e.g., consultants)
    a. Identify each, with purpose, and dollar rates
    b. Total estimated subcontracts costs (dollars)
16. Other direct costs (specify)
    a. Total estimated direct cost and overhead (dollars)
17. General and administrative expense
    a. Percentage rate applied
    b. Total estimated cost of G&A expense (dollars)
18. Royalties (specify)
    a. Estimated cost (dollars)
19. Fee or profit (dollars
20. Total estimate cost and fee or profit (dollars)
21. The cost breakdown portion of a proposal must be signed by a responsible official, and the person signing must have typed name and title and date of signature must be indicated.
22. On the following items offeror must provide a yes or no answer to each question.
    a. Has any executive agency of the United State Government performed any review of your accounts or records in connection with any other government prime contract or subcontract within the past twelve months? If yes, provide the name and address of the reviewing office, name of the individual and telephone extension.
    b. Will you require the use of any government property in the performance of this proposal? If yes, identify.
    c. Do you require government contract financing to perform this proposed contract? If yes, then specify type as advanced payments or progress payments.
23. Type of contract proposed, either cost-plus-fixed-fee or firm-fixed price.

U.S. DEPARTMENT OF DEFENSE

SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
FAST TRACK APPLICATION COVER SHEET

Failure to fill in all appropriate spaces may cause your application to be disqualified

To qualify for the SBIR Fast Track, a company must submit a Fast Track application and meet the other requirements detailed in Section 4.5 of the solicitation. This form, when completed and signed by both the company and its investor, should be included as the cover sheet of the Fast Track application. Instructions on where to submit the application are on the back of this form.

TOPIC #: ______________ CONTRACT #: ______________________ PHASE I EFFECTIVE START DATE: ______________

SPONSORING DOD COMPONENT: ______________________________ PHASE I COMPLETION DATE: ______________

PHASE I TITLE: ____

____

FIRM NAME: ____

MAIL ADDRESS: ____

CITY: ______________________ STATE: __________ ZIP: __________

TAXPAYER IDENTIFICATION NUMBER: ______________________

NAME OF OUTSIDE INVESTOR: ____

MAIL ADDRESS: ____

CITY: ______________________ STATE: __________ ZIP: __________

TAXPAYER IDENTIFICATION NUMBER: ______________________

BUSINESS CERTIFICATION:

	YES	NO
▸ Has your company ever received a Phase II SBIR or STTR award from the federal government (including DoD)? If yes, the minimum matching rate is $1 for every SBIR dollar. If no, the minimum matching rate is 25 cents for every SBIR dollar. (Matching rates differ slightly for BMDO applicants-- see the BMDO section of this solicitation)	☐	☐
▸ Does the outside funding proposed in this application qualify as a "Fast Track investment", and does the investor qualify as an "outside investor", as defined in DoD Fast Track Guidance (Reference E)? If you have any questions about this, call the DoD SBIR Help Desk (800-382-4634). The Help Desk will refer any policy and/or substantive questions to appropriate DoD personnel for an official response.	☐	☐

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PROPOSED SBIR AND MATCHING FUNDS:

- Proposed DoD SBIR funds for the interim effort: $______________
- Proposed DoD SBIR funds for Phase II: $______________
- Total proposed DoD SBIR funds (interim + Phase II): $______________
- Amount of matching funds (cash) the investor will provide: $______________

By signing below, the parties are stating that the outside investor will provide matching funds, in the amount listed above, contingent on the company's selection for Phase II SBIR award. If the matching funds are not transferred from the investor to the company within 45 days after DoD has notified the company that it has been selected for Phase II award, the company will be ineligible to compete for a Phase II award not only under the Fast track but also under the regular Phase II competition, unless a specific written exception is granted by the Component SBIR program manager.

COMPANY OFFICIAL

NAME: ______________________

TITLE: ______________________

TELEPHONE: ______________________

______________________ ________
SIGNATURE DATE

OUTSIDE INVESTOR OFFICIAL

NAME: ______________________

TITLE: ______________________

TELEPHONE: ______________________

______________________ ________
SIGNATURE DATE

INSTRUCTIONS FOR COMPLETING APPENDIX D

SUBMISSION:

Submit the Fast Track application, including the three items discussed in Section 4.5(b), to the technical monitor for your Phase I project. In addition, submit a copy of the entire application to the Program Manager of the DoD Component funding the SBIR project (addresses below). Finally, send a copy of this application cover sheet, when completed, to the DoD SBIR Program Manager, 3061 Defense Pentagon, Room 2A338, Washington, DC 20301-3061. Do not submit other items in the Fast Track application to the DoD SBIR Program Manager.

Department of the Army
Dr. Kenneth A. Bannister
Army SBIR Program Manager
Army Research Office - Washington
5001 Eisenhower Avenue, Room 8N23
Alexandria, VA 22333-0001

Department of the Navy
ONR 362 SBIR
800 N. Quincy Street
Arlington, VA 22217-5660

Department of the Air Force
AFPL/XPXP, Suite 6
ATTN: R.J. Dickman
Wright Patterson AFB, OH 45433-5006

Defense Advanced Research Projects Agency
ATTN: SBIR Program Manager Ms. C. Jacobs
3701 N. Fairfax Drive
Arlington, VA 22203-1714

Chemical and Biological Defense Program
Dr. Kenneth A. Bannister
Army Research Office - Washington
5001 Eisenhower Avenue, Room 8N23
Alexandria, VA 22333-0001

Ballistic Missile Defense Organization
ATTN: TOI/SBIR (Bond)
1725 Jefferson Davis Highway
Suite 809
Arlington, VA 22202

Office of the Director, Defense Research and Engineering
Lab Management & Tech Transition
ATTN: SBIR Program Manager
3040 Defense Pentagon
Washington D. C. 20301-3040

Defense Special Weapons Agency
ATTN: AM/SADBU, Mr. Bill Burks
6801 Telegraph Road
Alexandria, VA 22310-3398

US Special Operations Command
ATTN: SOSB/Ms Karen L. Pera
7701 Tampa Point Blvd.
MacDill AFB, FL 33621-5323

National Imagery and Mapping Agency
Dr. Young Suk Sull
Mail-Stop: P-53
12301 Sunrise Valley Drive
Reston, VA 20191-3449

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Minneapolis, MN 55425-1566
(800) 382-4634

U.S. DEPARTMENT OF DEFENSE

SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
FAST TRACK APPLICATION COVER SHEET

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TOPIC #: ______________ CONTRACT #: ______________________ PHASE I EFFECTIVE START DATE: ______________

SPONSORING DOD COMPONENT: ______________________ PHASE I COMPLETION DATE: ______________

PHASE I TITLE: ____

____

FIRM NAME: ____

MAIL ADDRESS: ____

CITY: ______________________ STATE: __________ ZIP: __________

TAXPAYER IDENTIFICATION NUMBER: ______________________

NAME OF OUTSIDE INVESTOR: ____

MAIL ADDRESS: ____

CITY: ______________________ STATE: __________ ZIP: __________

TAXPAYER IDENTIFICATION NUMBER: ______________________

BUSINESS CERTIFICATION:

	YES	NO
▸ Has your company ever received a Phase II SBIR or STTR award from the federal government (including DoD)? If yes, the minimum matching rate is $1 for every SBIR dollar. If no, the minimum matching rate is 25 cents for every SBIR dollar. (Matching rates differ slightly for BMDO applicants-- see the BMDO section of this solicitation)	☐	☐
▸ Does the outside funding proposed in this application qualify as a "Fast Track investment", and does the investor qualify as an "outside investor", as defined in DoD Fast Track Guidance (Reference E)? If you have any questions about this, call the DoD SBIR Help Desk (800-382-4634). The Help Desk will refer any policy and/or substantive questions to appropriate DoD personnel for an official response.	☐	☐

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PROPOSED SBIR AND MATCHING FUNDS:

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- Total proposed DoD SBIR funds (interim + Phase II): $______________
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COMPANY OFFICIAL	OUTSIDE INVESTOR OFFICIAL
NAME: ______________________	NAME: ______________________
TITLE: ______________________	TITLE: ______________________
TELEPHONE: ______________________	TELEPHONE: ______________________
SIGNATURE ______________ DATE ______	SIGNATURE ______________ DATE ______

INSTRUCTIONS FOR COMPLETING APPENDIX D

SUBMISSION:

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Department of the Army
Dr. Kenneth A. Bannister
Army SBIR Program Manager
Army Research Office - Washington
5001 Eisenhower Avenue, Room 8N23
Alexandria, VA 22333-0001

Department of the Navy
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Department of the Air Force
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Office of the Director, Defense Research and Engineering
Lab Management & Tech Transition
ATTN: SBIR Program Manager
3040 Defense Pentagon
Washington D. C. 20301-3040

Defense Special Weapons Agency
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US Special Operations Command
ATTN: SOSB/Ms Karen L. Pera
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MacDill AFB, FL 33621-5323

National Imagery and Mapping Agency
Dr. Young Suk Sull
Mail-Stop: P-53
12301 Sunrise Valley Drive
Reston, VA 20191-3449

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U.S. DEPARTMENT OF DEFENSE

SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
FAST TRACK APPLICATION COVER SHEET

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SPONSORING DOD COMPONENT: ____________________________________ PHASE I COMPLETION DATE: ______________

PHASE I TITLE: ____

____

FIRM NAME: ____

MAIL ADDRESS: ____

CITY: ______________________________ STATE: __________ ZIP: ____________

TAXPAYER IDENTIFICATION NUMBER: ______________________

NAME OF OUTSIDE INVESTOR: ____

MAIL ADDRESS: ____

CITY: ______________________________ STATE: __________ ZIP: ____________

TAXPAYER IDENTIFICATION NUMBER: ______________________

BUSINESS CERTIFICATION:

	YES	NO
▸ Has your company ever received a Phase II SBIR or STTR award from the federal government (including DoD)? If yes, the minimum matching rate is $1 for every SBIR dollar. If no, the minimum matching rate is 25 cents for every SBIR dollar. (Matching rates differ slightly for BMDO applicants-- see the BMDO section of this solicitation)	☐	☐
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COMPANY OFFICIAL	OUTSIDE INVESTOR OFFICIAL
NAME: ______________	NAME: ______________
TITLE: ______________	TITLE: ______________
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INSTRUCTIONS FOR COMPLETING APPENDIX D

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Department of the Army
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Army SBIR Program Manager
Army Research Office - Washington
5001 Eisenhower Avenue, Room 8N23
Alexandria, VA 22333-0001

Department of the Navy
ONR 362 SBIR
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Department of the Air Force
AFPL/XPXP, Suite 6
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Ballistic Missile Defense Organization
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Office of the Director, Defense Research and Engineering
Lab Management & Tech Transition
ATTN: SBIR Program Manager
3040 Defense Pentagon
Washington D. C. 20301-3040

Defense Special Weapons Agency
ATTN: AM/SADBU, Mr. Bill Burks
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US Special Operations Command
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National Imagery and Mapping Agency
Dr. Young Suk Sull
Mail-Stop: P-53
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U.S. DEPARTMENT OF DEFENSE

SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
FAST TRACK APPLICATION COVER SHEET

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SPONSORING DOD COMPONENT: ______________________ PHASE I COMPLETION DATE: ______________

PHASE I TITLE: ____

____

FIRM NAME: ____

MAIL ADDRESS: ____

CITY: ______________________ STATE: __________ ZIP: __________

TAXPAYER IDENTIFICATION NUMBER: ______________________

NAME OF OUTSIDE INVESTOR: ____

MAIL ADDRESS: ____

CITY: ______________________ STATE: __________ ZIP: __________

TAXPAYER IDENTIFICATION NUMBER: ______________________

BUSINESS CERTIFICATION:

	YES	NO
▸ Has your company ever received a Phase II SBIR or STTR award from the federal government (including DoD)? If yes, the minimum matching rate is $1 for every SBIR dollar. If no, the minimum matching rate is 25 cents for every SBIR dollar. (Matching rates differ slightly for BMDO applicants-- see the BMDO section of this solicitation)	☐	☐
▸ Does the outside funding proposed in this application qualify as a "Fast Track investment", and does the investor qualify as an "outside investor", as defined in DoD Fast Track Guidance (Reference E)? If you have any questions about this, call the DoD SBIR Help Desk (800-382-4634). The Help Desk will refer any policy and/or substantive questions to appropriate DoD personnel for an official response.	☐	☐

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COMPANY OFFICIAL	OUTSIDE INVESTOR OFFICIAL
NAME: ______________	NAME: ______________
TITLE: ______________	TITLE: ______________
TELEPHONE: ______________	TELEPHONE: ______________
SIGNATURE ______________ DATE ______	SIGNATURE ______________ DATE ______

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INSTRUCTIONS FOR COMPLETING APPENDIX D

SUBMISSION:

Submit the Fast Track application, including the three items discussed in Section 4.5(b), to the technical monitor for your Phase I project. In addition, submit a copy of the entire application to the Program Manager of the DoD Component funding the SBIR project (addresses below). Finally, send a copy of this application cover sheet, when completed, to the DoD SBIR Program Manager, 3061 Defense Pentagon, Room 2A338, Washington, DC 20301-3061. Do not submit other items in the Fast Track application to the DoD SBIR Program Manager.

Department of the Army
Dr. Kenneth A. Bannister
Army SBIR Program Manager
Army Research Office - Washington
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Department of the Air Force
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3040 Defense Pentagon
Washington D. C. 20301-3040

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ATTN: SOSB/Ms Karen L. Pera
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Reston, VA 20191-3449

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Additional forms may be downloaded from our Home Page (http://www.acq.osd.mil/sadbu/sbir). They may also be obtained from your State SBIR Organization (Reference D) or:

DoD SBIR Support Services
2850 Metro Drive, Suite 600
Minneapolis, MN 55425-1566
(800) 382-4634

U.S. DEPARTMENT OF DEFENSE

SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
COMPANY COMMERCIALIZATION REPORT

Failure to fill in all appropriate spaces may cause your proposal to be disqualified

FIRM NAME: ____________________

MAIL ADDRESS: ____________________

CITY: ____________________ STATE: __________ ZIP: __________

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FIRM CORPORATE OFFICIAL

NAME: ____________________ TELEPHONE: ____________________

TITLE: ____________________ FAX: ____________________

Before signing below, please read the cautionary note at Section 3.7

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U.S. DEPARTMENT OF DEFENSE

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COMPANY COMMERCIALIZATION REPORT

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Agency: __________ Topic Number: __________ Contract Number: __________

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FIRM CORPORATE OFFICIAL

NAME: ____________________ TELEPHONE: ____________________

TITLE: ____________________ FAX: ____________________

Before signing below, please read the cautionary note at Section 3.7

____________________ ____________________

SIGNATURE OF FIRM CORPORATE OFFICIAL DATE

INSTRUCTIONS FOR COMPLETING APPENDIX E

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Appendix E should be the last page(s) of your proposal.

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Submission:

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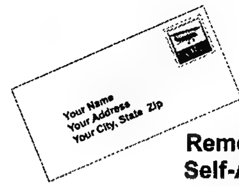
Reference A
DoD SBIR Solicitation 99.1

Proposer: If you wish to be notified that your proposal has been received, please submit this form with a stamped, self-addressed envelope.



Remember to Stamp Your Self-Addressed Envelope!

TO: ____

____

____

Fill in firm's name and mailing address

SUBJECT: SBIR Solicitation No. 99.1

Topic No. ____________
Fill in Topic No.

This is to notify you that your proposal in response to the subject solicitation and topic number has been received by

____
Fill in name of organization to which you will send your proposal.

____ ____________
Signature by receiving organization Date

DEFENSE TECHNICAL INFORMATION CENTER

SMALL BUSINESS INNOVATION RESEARCH PROGRAM REQUEST FOR TECHNICAL DOCUMENT SERVICES

Small Businesses are encouraged to obtain Technical Information Packages (TIPs), annotated bibliographies of technical reports from the Defense Technical Information Center (DTIC). A TIP is prepared for each SBIR topic. TIPs are free; a small business may order as many as needed. The technical reports cited in a TIP cover DoD-funded work related to the particular topic. Ten technical reports may be obtained at no cost from DTIC during SBIR Solicitations. See section 7.1 for a more detailed description of TIPs and other valuable SBIR services available from DTIC.

1. You may fold, stamp and mail this form. Remember, significant mailing delays can occur.

2. For faster service, you may also telephone, fax or Email requests, or obtain TIPs from the DTIC SBIR Web site.
   Phone: 800-363-7247
   FAX: 703-767-8228
   Email: sbir@dtic.mil
   WWW: http://www.dtic.mil/dtic/sbir

3. Technical reports of interest, in addition to those cited in the TIPs, can be identified using Public STINET, the online technical reports database, available on the DTIC SBIR web site. A large selection of Full-Text Documents, including many related to SBIR topics, is also available on the web site.

4. DTIC provides technical services under the SBIR program year-around. Authorization to provide free hard copy is in effect during solicitations only.

REQUESTER ______________________________
Name

ORGANIZATION NAME ______________________________

ADDRESS ______________________________
Street

______________________________ PHONE ______________________________
City State Zip Code Area Code/Number

FAX ______________________________ EMAIL ______________________________

Send technical reports bibliographies on the following SBIR topics:

TOPIC NUMBER	TOPIC NUMBER	TOPIC NUMBER	TOPIC NUMBER	TOPIC NUMBER
1 ________	5 ________	9 ________	13 ________	17 ________
2 ________	6 ________	10 ________	14 ________	18 ________
3 ________	7 ________	11 ________	15 ________	19 ________
4 ________	8 ________	12 ________	16 ________	20 ________

I confirm that the business identified above meets the SBIR qualification criteria in Section 2.2 of the DoD Program Solicitation.

Signature of Requester: ______________________________

Associate Directors of Small Business assigned at Defense Contract Management Districts (DCMD):
(DCMD EAST -- http://www.dcmde.dla.mil; DCMD WEST -- http://www.dcmdw.dla.mil)

DCMD EAST (DCMDE-DU)
ATTN: John T. McDonough
495 Summer Street, 8th Floor
Boston, MA 02210-2184
(617) 753-4318
(617) 7533174 (FAX)
bdu1199@dcmde.dal.mil

DCMC Atlanta (DCMDE-GADU)
ATTN: Mildred Jacobs
805 Walker Street
Marietta, GA 30060-2789
(770) 590-6197
(770) 590-6551 (FAX)
mjacobs@dcmde.dla.mil

DCMC Lockheed Martin Marietta (DCMDE-RHDU)
ATTN: Erma A. Peacock
86 South Cobb Drive, Building B-2
Marietta, GA 30063-0260
(770) 494-2016
(770) 494-7883 (FAX)
epeacock@dcmde.dla.mil

DCMC Baltimore (DCMDE-GTDU)
ATTN: Gregory W. Prouty
200 Towsontown Blvd, West
Towson, MD 21204-5299
(410) 339-4809
(410) 339-4990 (FAX)
agm0102@demde.dla.mil

DCMC Birmingham (DCMDE-GLDU
ATTN: Jim W. Brown
Burger Phillips Cneter
1910 3rd Avenue, N., Suite 201
Birmingham, AL 35203-3514
(205) 716-7403
(205) 716-7876 (FAX)
jibrown@dcmde.dla.mil

DCMC Boston (DCMDE-GFDU)
ATTN: Philip R. Varney
495 Summer Street
Boston, MA 02210-2184
(617) 753-3467/4110
(617) 753-4005 (FAX)
pvarney@dcrb.dla.mil

DCMC Clearwater (DCMDE-GCDU)
ATTN: Jim Masone
Gadsen Building
9549 Koger Blvd., Suite 200
St. Petersburg, FL 33702-2455
(813) 579-3093
(813) 579-3106 (FAX)
jmasone@dcmde.dla.mil

DCMC Cleveland (DCMDE-GZDU)
ATTN: Herman G. Peaks
555 E 88th Street
Cleveland, OH 44108-1068
(216) 681-1571
(216) 681-1719 (FAX)
bgz9205@dcro.dla.mil

DCMC Dayton (DCMDE-GYDU)
ATTN: Thomas E. Watkins
1725 Van Patton Drive, Building 30, Area C
Wright-Patterson AFB, OH 45433-5302
(937) 656-3104
(937) 656-3228 (FAX)
twatkins@dayton.dcro.dla.mil

DCMC Detroit (DCMDE-GJDU)
ATTN: David C. Boyd
Building 231
Warren, MI 48397-5000
(810) 574-4474
(810) 574-6078 (FAX)
dboyd@detroit.dcro.dla.mil

DCMC Hartford (DCMDE-GUDU)
ATTN: Carl Cromer
130 Darlin Street
East Hartford, CT 06108
(860) 291-7705
(860) 291-7992 (FAX)
ccromer@dcmde.dla.mil

DCMC Long Island (DCMDE-GGDU)
ATTN: Eileen Kelly
605 Stewart Street
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DoD Fast Track Guidance

This paper contains DoD's official guidance on what types of relationships between a small company and outside investors in the company qualify as an investment under the SBIR and STTR Fast Track ("Fast Track investment"). It includes specific examples of company-investor relationships that we have been asked about and our official responses on whether these relationships qualify as a Fast Track investment. If you have questions about whether a particular company-investor relationship qualifies, please contact the DoD SBIR/STTR Help Desk (tel. 800/382-4634, fax 800/462-4128, e-mail SBIRHELP@us.teltech.com). The Help Desk will refer any policy or substantive questions to appropriate DoD personnel for an official response.

I. General Guidance on What Qualifies As A "Fast Track Investment"

- The investor must be an "outside investor," which may include such entities as another company, a venture capital firm, an individual "angel" investor, a non-SBIR/non-STTR government program, or any combination of the above. It does not include the owners of the small business, their family members, and/or "affiliates" of the small business, as defined in Title 13 of the Code of Federal Regulations (C.F.R.), Section 121.103. As discussed in that Section:
  - Concerns are affiliates of each other when one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.
  - [We] consider factors such as ownership, management, previous relationships with or ties to another concern, and contractual relationships, in determining whether affiliation exists.
  - Individuals or firms that have identical or substantially identical business or economic interests, such as family members, persons with common investments, or firms that are economically dependent through contractual or other relationships, may be treated as one party with such interests aggregated.

  Although DoD is guided by this definition of affiliation in the Code of Federal Regulations, we also exercise our own discretion in determining whether a particular entity qualifies as an "outside investor."

- The <u>investment</u> must be an arrangement in which the outside party provides cash to the small company in return for such items as: equity; a share of royalties; rights in the technology; a percentage of profit; an advance purchase order for products resulting from the technology; or any combination of the above. The investor's funds must pay for activities that further the development and/or commercialization of the company's SBIR technology (e.g., further R&D, manufacturing, marketing, etc.).

II. Specific examples of What Does and Does Not Qualify As a "Fast Track Investment"

<u>A. Examples of What Qualifies as an "Outside Investor"</u>

(1) Can a small company contribute its own internal funds to qualify for the Fast Track?

No. DoD is seeking outside validation of the commercial potential of the company's technology, and therefore requires that the funds come from an outside investor. Also, cash from an outside investor shows up plainly on the company's books and therefore can be more readily verified than a company's own matching contribution.

(2) Company A spins off company B, which wins a phase I SBIR award. Company A then wants to contribute matching funds to qualify company B for the Fast Track. Can A be considered an outside investor for purposes of the Fast Track?

In making our determination of whether company A is an outside investor, we would be guided by the definition of "affiliates" in 13 C.F.R. Sec. 121.103, discussed above. Our presumption is that in this example A and B would be considered "affiliates," and that A would therefore not be an outside investor for purposes of the Fast Track. However, that presumption could be rebutted by showing, for example, that the spin-off occurred several years ago and that A and B do not exercise control over one another, do not have common ownership or management, have different business interests, etc.

(3) Small company S wins a phase I SBIR award. The president of S is a major shareholder in another company Y, which wants to contribute matching funds to qualify S for the Fast Track. Can Y be considered an outside investor?

Our presumption is that Y would not be considered an outside investor. Our determination would be guided by whether the president's stake in Y is large enough that S and Y would be considered "affiliates" under 13 C.F.R. Sec.121.103. Subsection (c.) of Section 121.103 specifically discusses affiliation based on stock ownership:

c. Affiliation based on stock ownership.
   1. A person is an affiliate of a concern if the person owns or controls, or has the power to control 50 percent or more of its voting stock, or a block of stock which affords control because it is large compared to other outstanding blocks of stock.
   2. If two or more persons each owns, controls or has the power to control less than 50 percent of the voting stock of a concern, with minority holdings that are equal or approximately equal in size, but the aggregate of these minority holdings is large as compared with any other stock holding, each such person is presumed to be an affiliate of the concern. If S and Y are found to be affiliates, we would determine that Y is not an outside investor.

(4) Does the outside investor have to be a single entity (e.g., a single venture capital firm) or can it be more than the entity (e.g., two angel investors and a venture capital firm)?

It can be more than one entity.

(5) Small company A contributes matching funds to small company B in order to qualify B for the Fast Track, and, at the same time, B contributes matching funds to A in order to qualify A for the Fast Track. Do A and B qualify as outside investors under the Fast Track?

No. A and B's relationship is such that their investment in each other would not provide outside validation of the commercial potential of their respective SBIR projects. We would therefore not consider them to be outside investors for purposes of the Fast Track.

(6) Can the brother of an employee of small company S contribute funds to qualify S for the Fast Track?

Probably not. Again, we would be guided by the definition of "affiliates" in 13 C.F.R. Sec. 121.103. The brother presumptively would be an affiliate of company S and not an outside investor.

(7) Venture capital firm V currently is a 22 percent shareholder in small company S. Can V invest additional funds in S to qualify S for the Fast Track?

Our presumption is yes. In making our determination, we would be guided by whether V and S are "affiliates," as defined in 13 C.F.R. Sec. 121.103. Section 121.103 provides (in subsection (b)(5)) that a venture capital firm is not affiliated with a company if the venture capital firm does not control the company -- e.g., by owning more than 50 percent of the stock of a small company (prior to its investment under the Fast Track), as described in 13 C.F.R. 107.865.

(8) Large company L makes a cash investment in small company S, and then serves as a subcontractor to S on an SBIR project. Can L's investment in S count as a matching contribution for purposes of the Fast Track?

Only L's cash investment net of its subcontracting effort can count as matching funds for purposes of the Fast Track. For example, if L invests $750,000 in S and subcontracts with S for $250,000, only L's net contribution ($500,000) can count as matching funds for purposes of the Fast Track.

(9) Company Y makes a cash investment in small company S for purposes of the Fast Track, and also enters into a separate contract with S under which Y provides certain goods/services to S in return for $500,000. Can Y's cash investment in S count as a matching contribution for purposes of the Fast Track?

As in the previous example, only Y's cash investment net of the $500,000 it receives from S can count as matching funds for purposes of the Fast Track. However, if the separate contract between Y and S pre-dates S's submission of its phase I SBIR proposal, Y's entire cash investment can count as matching funds for purposes of the Fast Track.

(10) A group of investors wishes to invest funds in small company S to qualify S for the Fast Track. One of the investors is the mother of S's president, who wants to contribute $50,000 toward the effort. Can the group's investment in S count as a matching contribution to qualify S for the Fast Track?

The mother's investment of $50,000 does not count, because she is not an outside investor (see item (6) above). Contributions of the other investors can count provided that they meet the other conditions for the Fast Track (e.g., each must be an outside investor).

<u>B. Examples of What Qualifies as an "Investment"</u>

(1) Can a loan from an outside party qualify as an "investment" for purposes of the Fast Track?

No. The rationale behind the Fast Track is that an outside party is betting on the company's success in bringing the technology to market -- not just its ability to repay a loan.

(2) How about a loan that is convertible to equity?

A loan that is convertible to equity at the company's discretion would count as an investment under the following circumstances: (1) the loan is provided by a public entity (e.g., a state agency), or (2) the loan is provided by a private entity, and the SBIR company actually converts the loan to equity before the end of phase I.

(3) Can in-kind contributions from an outside investor count as matching funds under the Fast Track?

No. The matching contribution must be in cash. A cash contribution is a stronger signal of the outside investor's interest in the technology, and can be readily verified.

(4) Can a purchase order from an outside investor count as a matching contribution under the Fast Track?

An advance purchase order for new products resulting from the SBIR project can count as a matching contribution under the Fast Track. The purchase order must be for one or more products directly resulting from the SBIR project (including, for example, a duplicate of the prototype that will be delivered to DoD at the end of phase II). The investor must provide its cash payment to the small business during phase II, within the time frame set out in the solicitation (section 4.5). To ensure that the investor's funds are "at risk," the payment cannot be refundable to the investor if the product is not delivered or does not work.

(5) Can the funds raised from an initial public offering (IPO) count as matching funds for purposes of the Fast Track?

Yes, as long as the offering memo indicates that a portion of the funds from the IPO will pay for work (e.g., R&D, marketing, etc.) that is related to the SBIR project.

(6) If large company L pays small company S for work related to S's SBIR project and expects a deliverable (goods or services) from S in return, would that qualify as an "investment"?

With the exception of an advance purchase order (discussed in (4) above), this arrangement would not qualify as an investment, for the same reason a loan does not qualify. Specifically, in this situation the large company is not betting on the small company's success in bringing the technology to market, but merely on its ability to provide the deliverable.

C. Examples Re: Timing/Logistics of the Fast Track Investment

(1) Can entity E's investment in small company S during the first month of S's phase I SBIR project count as a matching contribution to qualify S for the Fast Track?

Yes, provided that E is an outside and that the other Fast Track conditions are met. The investment can occur any time after the start of the phase I project.

(2) Small company A, which has won a phase I award, spins off small company B to commercialize the SBIR technology. A then convinces angel investor I to invest funds in B. Can I's investment in B count as a matching contribution to qualify A for the Fast Track?

For I's investment in B to qualify A for the Fast Track, DoD must determine that A and B are substantially the same entity, as evidenced, for example, by their meeting the definition of "affiliates" in 13 C.F.R. Sec.121.103. If DoD determines that A and B are substantially the same entity, I's investment in B could qualify A for the Fast Track. Of course, the parties must also meet the other conditions for the Fast Track (e.g., I must be an outside investor).

(3) Small company S is collaborating with a university on an STTR project. Investor I wishes to provide funds to the university in order to qualify S for the STTR Fast Track. Can I's investment in the university count as a matching contribution to qualify S for the Fast Track?

In order to qualify S for the STTR Fast Track, I's investment of funds must be in small company S, not in the university. S can then subcontract some of the funds to the university. The rationale is that a cash investment in the small company is a very strong indication of commercial potential, whereas an investment in the university is less so.

(4) Must the activities funded by the investor be included in the statement of work for the small company's phase II contract?

No. The investor's funds must pay for activities that further the development and/or commercialization of the company's SBIR technology (e.g., further R&D, manufacturing, marketing, etc.), but these activities need not be included in the phase II contract's statement of work. In practice, funds from private sector Fast Track investors generally are not included in the phase II contract's statement of work, whereas funds from government Fast Track investors (such as DoD acquisition programs) sometimes are.

DoD's Critical Technologies
(Defense Technology Area)

1.	**Aerospace Propulsion and Power** -- technology directed toward propulsion and power systems for aircraft, missiles, and space vehicles in four major sub-areas: 1) gas-turbine propulsion systems for aircraft and cruise missiles; 2) propulsion systems for space and missile systems; 3) ramjet, scramjet, combined cycle propulsion systems for missile and space-launch systems and fuels; 4) non-propulsive power generation systems for aircraft, missiles, and space vehicles.
2.	**Air Vehicles/Space Vehicles** -- Air vehicles: technology of aeromechanics, flight controls, subsystem, air vehicle structures in fixed wing vehicles, rotary wing vehicles, unmanned air vehicles, and system integration technology. Space Vehicles: technology oriented toward the spacecraft bus, technologies unique to space and the military and their implementation through flight experiments in the following sub-areas: 1) thrust producing engines and devices for space launch, orbit transfer, and maneuver; 2) generation and distribution of electrical power on-board spacecraft; 3) thermal management for all satellite applications; 4) structures focused on adapting advanced materials and structures produced in basic research for space applications; 5) survivability focused on "environments" (both natural and hostile) and "techniques" (including active and passive approaches); 6) guidance, navigation, and control for the launch from earth, earth orbit and free space; 7) technology integration focused on adapting products of other technology areas to space systems; 8) flight experiments which focus on space qualification and transfer of technology to the military and civilian space communities.
3.	**Battlespace Environments** -- study, characterization, prediction, modeling, and simulation of the terrestrial, ocean, lower atmosphere, and space/upper atmosphere environments to understand their impact on personnel, platforms, sensors, and systems; enable the development of tactics and doctrine to exploit that understanding; and optimize the design of new systems.
4.	**Biomedical** -- yield superior technology in support of the DoD mission to provide health support to U.S. military forces by preserving the combatant's optimal mission capabilities and health despite battle and non-battle threats from military operations. Medical research programs must be conducted for the benefit of mankind and many are regulated by the U.S. Food and Drug Administration.
5.	**Chemical and Biological Defense** -- U.S. forces must be prepared for conflict in a chemical and biological environment in a Global Reach concept. The CB defense technology area includes four major subareas: 1) detection; 2) protection; 3) decontamination, and 4) information processing and dissemination.
6.	**Clothing, Textiles and Food** -- focuses on protecting and sustaining soldiers, sailors, airmen, and marines, individually and collectively. This technology includes two sub-areas: 1) Clothing and textiles - includes all textile-related polymer, fiber, yarn, fabric, film, dye, pigment, coating, and clothing systems and their packaging which enhance survivability, performance, and mobility. These efforts provide ballistic protection, percutaneous chemical/biological protection, countermeasures to sensors, integrated protection (flame/incendiary and anthropometric/biomechanical concepts), and bioengineered materials for protection. This subarea includes textile based technologies for items such as tentage and parachutes. 2) Food -- includes science and technological efforts to sustain warriors and enhance their mental and physical acuity and performance by nutritional performance enhancement, food preservation, food packaging, consumer acceptance, and equipment and energy technologies. This technology area supports the unique feeding requirements of the military services ranging from general purpose individual rations to group ration systems for special operations.

7. **Command, Control and Communications (C3)** -- area encompasses C3 systems of all types: data processing hardware and software dedicated to operational planning, monitoring or assessment (including information fusion), distributed processing, distributed data storage, and distributed data management. **NOT INCLUDED:** general purpose computer hardware and high performance computers, general purpose software, languages, software engineering, environments, and communications and processing elements considered subsystems in vehicles.

8. **Computing and Software** -- push the frontiers of advanced information technology beyond that normally achieved by the commercial sector alone, to enable creation of broad range advanced information processing systems of critical value in support of the missions of the DoD. This area is separated into six broad subareas: 1) system software; 2) software and systems development; 3) intelligent systems; 4) user interface; 5) computing systems and architecture; and 6) networking.

9. **Conventional Weapons** -- develop conventional armament technologies for all new and upgraded non-nuclear weapons which includes efforts directed specifically toward non-nuclear munitions, their components, and launching systems, guns, bombs, guided missiles, projectiles, special warfare munitions, EOD devices, mortars, mines, countermine systems, torpedoes, and underwater weapons and their associated combat control. There are six major sub-areas: 1) fuzing/safe & arm; 2) guidance and control; 3) guns; 4) countermine/mines; 5) warheads and explosives; and 6) weapon lethality/vulnerability.

10. **Electronics** -- extends from basic research to applications at the subsystem level. The electronics technology area includes research, development, design, fabrication, and testing of electronic materials; electronic devices, including digital, analog, microwave, optoelectronic, vacuum and integrated circuits; and electronic modules, assemblies, and subsystems organized into five sub-areas: 1) RF components; 2) electro-optics; 3) microelectronics; 4) electronic materials; and 5) electronic models and subsystems.

11. **Electronic Warfare/Directed Energy Weapons** -- Electronic Warfare: Develop technology for the offensive and defensive application of EW which includes efforts in intercept, counter, and exploit the complex threat weapons spanning the entire electromagnetic spectrum, including radio frequency (RF), infrared (IR), electro-optic (EO), ultraviolet (UV), and multispectral/multimode sensors. Electronic Warfare is divided in three subareas: 1) force protection; 2) Offensive EW; and 3) EW support functions. Directed Energy Weapons: Technologies relate to the production and projection of a beam of concentrated electromagnetic energy or atomic/subatomic particles. The DEW technology is divided into three sub-areas: 1) laser weapons; 2) RF weapons; and 3) particle beam weapons.

12. **Environmental Quality/Civil Engineering** -- Environmental Quality: technologies which reduce the costs of DoD operations while ensuring mission accomplishment is not jeopardized by adverse environmental impacts. There are four sub-areas: 1) cleanup of contaminated sites resulting from DoD operations; 2) compliance with laws concerning the treatment and disposal of hazardous waste products; 3) pollution prevention; 4) conservation of natural and cultural resources. Civil Engineering: technology efforts to solve critical DoD civil engineering problems related to training, mobilizing, deploying, and employing a force at any location at any time. This technology area includes survivability and protective structures, airfields and pavements, conventional facilities, critical airbase facilities and recovery, ocean and waterfront facilities and operations, sustainment engineering, and fire fighting.

13. **Human Systems Interface** -- technology fully leverages and extends the capabilities of warfighters and maintainers to ensure that fielded systems will exploit the fullest potential of the warfighting team, irrespective of gender, mission or environment. This technology is organized into four areas: 1) crew systems integration and protection; 2) performance aiding; 3) information management and display; and 4) performance assessment and design methodologies.

14. **Manpower, Personnel and Training** -- Manpower and personnel technology addresses the recruitment, selection, classification, and assignment of people to military jobs. It seeks to reduce the attrition of high-quality personnel and helps the senior department leadership to predict and measure the consequences of policy decisions. Training systems technology improves the effectiveness of DoD's investment in training instruction, improves the efficiency of student flow through the training pipeline, enhances military training systems, provides opportunities for skill practice and mission rehearsal, and lowers life-cycle costs of training systems and combat systems.

15. **Materials, Processes and Structures** -- technologies produce an enabling array of capabilities for every DoD system that flies in air or space, navigates on land or over/under the sea, and fires or is fired upon. MP&S spans all material categories -- metal and intermetallic alloys; ceramics; polymers; composites of all types; semiconductors; superconductors, optical, ferroelectric, and magnetic materials; and materials for power sources.

16. **Sensors** -- technologies are divided into five major sub-areas: 1) radar sensors; 2) electro-Optic sensors; 3) acoustic sensors; 4) automatic target recognition; and 5) integrated platform electronics and sensors. Applications include strategic and tactical surveillance, identification and targeting of threats from all military platforms including satellites, aircraft, helicopters, ships, submarines, ground vehicles and sites, unmanned air vehicles, unattended ground sensors and the individual soldier.

17. **Surface/Under Surface Vehicles/Ground Vehicles** -- Surface/Under surface vehicles: technology for improved combat efficiency, survivability, and stealth of surface ships, submarines and unmanned undersea vehicles. Ground vehicles: technologies to support the basic Army and Marine Corps land combat functions: shoot, move, communicate, survive and sustain. Covered here are propulsion and power, track and suspension, vehicle subsystems, hydrodynamics, signature reduction, fuels and lubricants and integration technologies related to land combat vehicles, including amphibious vehicles with a ground combat role.

18. **Manufacturing Sciences and Technology (MS&T)** -- area is focused on cross-cutting engineering and manufacturing process technologies beyond those developed in conjunction with new product technologies in the other technology areas. Includes ARPA 6.2 and 6.3 programs in information technology for manufacturing applications, Service/DLA manufacturing technology (ManTech) programs, advanced technology demonstrations for affordability, and advanced industrial practices to demonstrate the combination of improved process technology and improved business practices. These programs encompass process technologies at all manufacturing levels (enterprise/factory/cell/machine/unit process).

19. **Modeling and Simulation (M&S)** -- includes development, integration, and implementation of tools and applications to apply M&S more broadly and with greater validity across DoD. Directly dependent on enabling technologies such as high speed computing, communications and networking, human systems interfaces, and software. Major sub-areas are: 1) architectures (software, data/database methodologies, and interfaces with communications and networks); 2) environmental representations (terrain, weather, atmosphere, space, oceans, and others); and 3) computer generated forces (systems representations, human behaviors, and their interactions).

Note: The above information is a summary of the information contained in documents "Defense Technology Plan" (DTIC # A285415) and "Defense Science and Technology Strategy" (DTIC # A285414).

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